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Neogene Paleontology in the northern Dominican Republic

8. The Family Muricidae (Mollusca: Gastropoda)

by

Emily H. Vokes

9. The Family Cardiidae (Mollusca: Bivalvia)

by

Harold E. Vokes

Paleontological Research Institution
1259 Trumansburg Road
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Emily H. Vokes

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Harold E. Vokes

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NEOGENE PALEONTOLOGY IN THE NORTHERN DOMINICAN REPUBLIC

8. The Family Muricidae (Mollusca: Gastropoda)

By

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ABSTRACT

The Neogene formations of the Yaque Group, Dominican Republic, include the following units: the Baitoa, Cercado, and Gurabo formations and the Mao Formation, including the Mao Adentro Limestone and Mao Clay members. The muricid fauna of the group is especially rich, with a total of 61 species divided into 34 subgenera. Prior to this report 19 species were known from the Dominican beds. This report adds 17 previously-described forms to the fauna.

A total of 23 new species of Muricidae are described, one of which had been previously reported by Maury (1917) under an erroneous name. New species occurring in both the Cercado and Gurabo formations are: *Murex* (?*Haustellum*) *adelosus*, *Chicoreus* (*Phyllonotus*) *pomatus*, *Dermomurex* (*Trialatella*) *pterynoides*, and *Spinidrupa* *radwini*. New species confined to the Gurabo Formation include: *Chicoreus* (*Siratus*) *amplius*, *Chicoreus* (*Siratus*) *eumekes*, *Pterynotus* (*Pterynotus*) *aliculus*, *Pterynotus* (*Pterynotus*) *neotripteris*, *Pterynotus* (*Purpurellus*) *mirificus*, *Dermomurex* (*Dermomurex*) *olssoni* (= *Aspella* *scaliarioides* of Maury), *Dermomurex* (*Dermomurex*) *granulatus*, *Dermomurex* (*Dermomurex*) *cracensis*, *Muricopsis* *quisqueyensis*, *Murexsul* *mimicus*, *Favartia* (*Favartia*) *zalaya*, *Siphonochelus* (*Laevityphis*) *spinirectus*, and *Spinidrupa* *demissa*. Two new species from the Baitoa Formation are: *Chicoreus* (*Chicoreus*) *corrigendum* and *Siphonochelus* (*Laevityphis*) *apheles*; and from the Cercado Formation there are four: *Chicoreus* (*Chicoreus*) *enigmaticus*, *Urosalpinx* *denticulatus*, *Thais* (*Stramonita*) *quadridentata*, and *Cymia* *marcano*.

In addition, three undescribed forms are figured and discussed, one from the Cercado and Gurabo formations, one from the Mao Formation, and one from an older unit in the southern part of the island that has been correlated with the Gurabo Formation by Bermúdez (1949), but which proves to be middle Miocene in age.

Due to the lack of correlative units in the western Atlantic region, there appears to be a high degree of endemism in the faunas of the Cercado-Gurabo formations. Of the 48 species of Muricidae in these two units, 29 are unique to the Dominican Republic, 21 being new taxa described herein. Only 19 species occur elsewhere, either in the Recent (12) or in other units in the Caribbean area.

In contrast, the Baitoa Formation has no endemic species. This is doubtless a reflection of the presence of other beds of the same age in Florida, Haiti, and Venezuela, as well as the shallow-water environment of deposition of the beds. The Mao Formation has no unique forms either, all but two being present also in the Recent; these exceptions are from the Gurabo Formation.

The shallow-water Baitoa Formation contains but 10 muricid species. The equally shallow-water Cercado Formation has 20 muricid species. The deep-water Mao Formation has yielded only eight muricid species but the intermediate to deep-water Gurabo Formation has 42 muricid species. Of this total of 61 species, 17 also occur in the Recent fauna and another 11 have closely related living descendants, so that the paleobathymetry of the formations is approximately as follows: the Baitoa and Cercado formations were deposited in water of 0 to 20 m depth; the more shallow portions of the Gurabo Formation, including the coralline facies, in 20 to 50 m; the moderately deep, typical Gurabo Formation in 50 to 150 m; and the very deep Gurabo Formation in 150 to 350 m. The Mao Formation was deposited in water deeper than 350 m; however, gravity-flows have brought more shallow material into the formation.

RESUMEN

Las formaciones del Neogeno del Grupo Yaque de la República Dominicana incluyen las unidades siguientes: las formaciones Baitoa, Cercado, y Gurabo, y la Formación Mao, que incluye los miembros Caliza Mao Adentro y Arcilla Mao. La fauna de la familia Muricidae del Grupo es bastante rica, con un total de 61 especies divididas en 34 sub-géneros. Antes de este informe, se conocían 19 especies de origen dominicano. Este noticia añade a la fauna 17 formas ya descritas.

Se describe un total de 23 especies nuevas de la familia Muricidae, una de las cuales que había sido reportada anteriormente por Maury (1917), bajo un nombre erróneo. Especies nuevas ocurren tanto en la Formación Cercado como en la Gurabo se encuentran: *Murex* (?*Haustellum*) *adelosus*, *Chicoreus* (*Phyllonotus*) *pomatus*, *Dermomurex* (*Trialatella*) *pterynoides*, y *Spinidrupa* *radwini*. Especies nuevas restringidas a la Formación Gurabo incluyen: *Chicoreus* (*Siratus*) *amplius*, *Chicoreus* (*Siratus*) *eumekes*, *Pterynotus* (*Pterynotus*) *aliculus*, *Pterynotus* (*Pterynotus*) *neotripteris*, *Pterynotus* (*Purpurellus*) *mirificus*, *Dermomurex* (*Dermomurex*) *olssoni* (= *Aspella* *scaliarioides* de Maury), *Dermomurex* (*Dermomurex*) *granulatus*, *Dermomurex* (*Dermomurex*) *cracensis*, *Muricopsis* *quisqueyensis*, *Murexsul* *mimicus*, *Favartia* (*Favartia*) *zalaya*, *Siphonochelus* (*Laevityphis*) *spinirectus*, y *Spinidrupa* *demissa*. Hay dos especies nuevas en la Formación Baitoa: *Chicoreus* (*Chicoreus*) *corrigendum* y *Siphonochelus* (*Laevityphis*) *apheles*. De la Formación Cercado hay cuatro: *Chicoreus* (*Chicoreus*) *enigmaticus*, *Urosalpinx* *denticulatus*, *Thais* (*Stramonita*) *quadridentata*, y *Cymia* *marcano*.

Además, se ilustran y discuten tres formas, aun no descritas, una de las formaciones Cercado y Gurabo, una de la Formación Mao, y otra perteneciente a una unidad más antigua de la parte sureña de la isla que antes se había correlacionado con la Formación Gurabo, pero que ahora ha probado ser del Mioceno medio.

Por falta de unidades correlacionables en la región del Atlántico occidental, hay un alto proporción de endemismo en las formaciones Cercado y Gurabo. De las 48 especies de Muricidae en estas dos unidades, 29 se conocen solamente en la región dominicana, 21 de las cuales son nuevas y se describen en este informe. Solo 19 de estas especies ocurren en el Reciente (12) o en otras unidades del área Caribe.

Por contraste, en la Formación Baitoa no ocurren especies endémicas, seguramente un reflejo de la existencia de otras unidades de la misma edad en la Florida, Haití, y Venezuela, y porque estos lechos se hallan en aguas de poca profundidad. La Formación Mao tampoco tiene especies endémicas; con la excepción de dos especies que se encuentran en la Formación Gurabo, las otras se hallan presentes en el Reciente también.

Hay solamente 10 especies de Muricidae en la Formación Baitoa, una unidad depositada en aguas de poca profundidad. La Formación Cercado, también depositada en aguas someras, cuenta con 20 especies. La Formación Mao, de aguas profundas, ha producido solamente ocho especies de Muricidae, pero la Formación Gurabo, una unidad depositada en aguas profundas hasta intermedias, contiene 42 especies. De este total de 61 especies, 17 ocurren también en la fauna Reciente y 11 tienen descendientes vivos muy parecidos, así que la paleobatimetría de las formaciones es aproximadamente como: las formaciones Baitoa y Cercado fueron depositadas en aguas desde 0 a 20 m; las porciones de menos profundidad de la Formación Gurabo, que incluyen las facies de corales, en 20 a 50 m; la Formación Gurabo típica, en 50 a 150 m; y la parte más honda de la Formación Gurabo, en 150 a 350 m. La Formación Mao proviene de aguas de más de 350 m de profundidad; sin embargo, las corrientes de gravedad han traído material de menos profundidad hasta a la formación.

INTRODUCTION

The fossil molluscan faunas of the island of Hispaniola first came to the attention of the paleontologists of the world when Sowerby (1850) described a small collection presented to the Geological Society of London by T. S. Heneken ("J. S. Heniker" in the original publication), a British Army officer. Of the 59 new species named by Sowerby, only two are referable to the Muricidae. Not surprisingly, one (*Murex* [= *Chicoreus* (*Siratus*)] *domingensis* Sowerby, 1850) is the most abundant muricid species to be found, but the other (*Typhis alatus* Sowerby, 1850) is among the rarer.

Sowerby's work, part of a longer article on the geology of the area, was followed in 1873 by a monograph on the geology, geography, and paleontology of the Republic of Santo Domingo (now the Dominican Republic) by William M. Gabb. Although Gabb's work was a masterful study and is still very usable, his paleontology was marred by two flaws — no illustrations and no locality data. As he believed all of the fossils came from the same "Miocene formation", he saw no need to keep a record of where he had stuffed them in his pockets.

Illustrations have been provided subsequently by Maury (1917) and Pilsbry (1922), who between them figured most of the species cited by Gabb. Maury also added locality data for some, and it is the purpose of this paper to clarify the remainder.

In addition to the two taxa described by Sowerby, Gabb described six species of Muricidae, with three others being cited under the names of Recent forms. One of the latter was soon described by Guppy (1876), who used the information provided by Gabb to rework the collections of the London Geological Society. Maury (1917) added two more new species, renamed one of Gabb's "Recent" forms and one homonym, and figured another addition to the fauna misidentified as

a Recent Mediterranean species (named herein as *Deromurex olssoni*, p. 59). Pilsbry and Johnson (1917) named one new species and Pilsbry (1922) figured five of Gabb's type specimens, separating one of Gabb's additional specimens as a subspecies of one of Maury's species, but it is herein considered a synonym. Vokes (1970a) added one, and more recently (E. H. Vokes, 1977, 1979; Vokes and D'Attilio, 1980) three others have been added, for a total of 19 species of Muricidae known to occur in the Neogene of the Dominican Republic prior to this report.

From 1976 to 1983 my husband and I spent a total of seven months (in ten trips) collecting the magnificent Dominican fossils. Much of the locality data came from the Maury expedition, in which the field work was done by Axel Olsson and Karl Schmidt. As Maury (1917, p. 167) observed, their work "involved wading up rivers, carrying heavy packs of fossils, sleeping in the roughest of shanties, and undergoing the greatest discomforts." In addition to the natural discomforts, the party was harassed by rebels and ultimately had to flee the country for their lives. Considering the conditions under which they worked the amount of information and fossils they collected is amazing. A few years after their labors, political stability was again restored (for a time) and the new government invited the U. S. Geological Survey to come in and conduct a study of the country. This resulted in a comprehensive analysis of the geology (Vaughan *et al.*, 1921), with many fossil localities enumerated but only brief faunal lists to document the stratigraphy. Nevertheless, the locality information proved to be a gold mine for our work.

While we were happily collecting fossils in the Dominican Republic, we were unaware that in Switzerland Peter Jung and John Saunders, of the Naturhistorisches Museum, Basel, were putting together a multidisciplinary study of the biostratigraphy and pa-

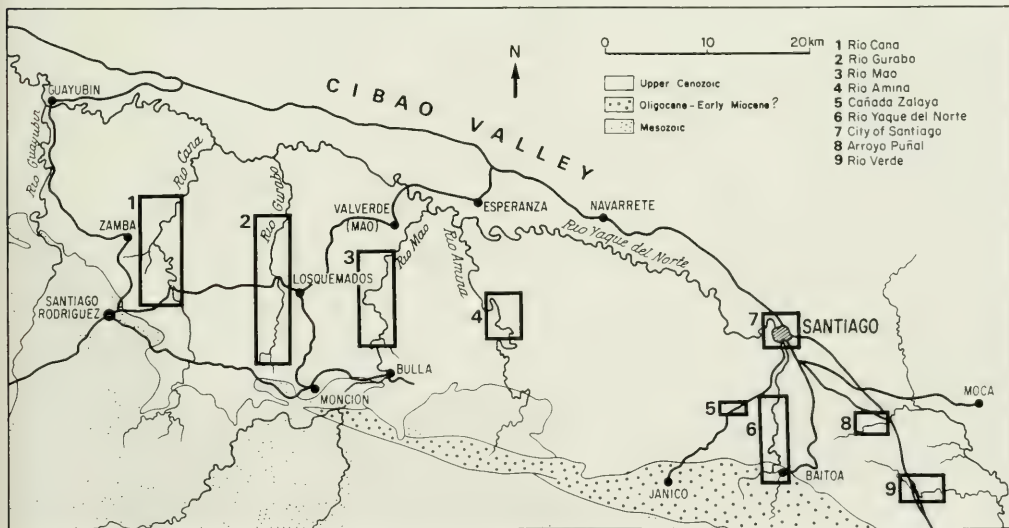
leoecology of the Neogene of the Dominican Republic, to be funded by the Swiss National Science Foundation and the Institut Français du Pétrole. With a group of surveyors, sedimentologists, micro- and mega-paleontologists, they began their work in 1978, making detailed stratigraphic measurements as well as maps. The results of their work are documented in Saunders, Jung, and Biju-Duval (1986).

We soon were apprised of their work by a mutual friend, Willem van den Bold, ostracode specialist at Louisiana State University, Baton Rouge, LA, who was part of their team. The obvious course was to pool our resources. Our megafossil collections have been made available to any specialist who desires to participate. In return, the muricids collected by the NMB workers were sent to Tulane to be incorporated into this study. Thus, the present paper is based upon both the collections made by us and by the NMB team (Text-fig. 1).

The original (and subsequent) philosophies of the Basel Project and the Vokes' collections were not the same. The Basel team went with the express goal of producing a detailed (and accurate) stratigraphic section. Our interest was primarily paleontologic with the goal being to localize the numerous unlocalized species described by Gabb and others and to collect as many different localities as possible. The Basel team concentrated almost all of their efforts on the Río Cana and Río Gurabo sections, with lesser concentration on the Río Amina, Río Mao, and Río Yaque del Norte. We

collected everywhere we could manage to get to, not only on the rivers but along roadcuts and trails between the rivers. Localities in some cases overlap, but in the interest of scientific accuracy they have been cited separately — Tulane localities as "TU" and those of the Naturhistorisches Museum Basel as "NMB". The Tulane University collecting localities have been indicated on the maps published by Saunders, Jung, and Biju-Duval (1986): Río Gurabo, text-fig. 5; Río Yaque del Norte, text-fig. 21; Río Mao, text-fig. 29; Río Amina, text-fig. 34; Arroyo Zalaya, text-fig. 36; Arroyo Puñal, text-fig. 37; and Río Verde, text-fig. 38. The end result is a collection that is unequalled anywhere in the world and, for the first time, one with exact stratigraphic control (see Saunders, Jung, and Biju-Duval, 1986, table 3).

In the 70 years since Olsson and Schmidt slept in chicken coops and battled rain, mud, and revolutionaries, things have improved in the Dominican Republic. The main roads are now paved, although by no means all that are necessary to get access to some of the localities — many are no different than they were 70 years ago. Accommodations are vastly improved — never did we have to settle for less than an air-conditioned (when the electricity was working!), first-class hotel. And certainly the people were much more friendly — instead of threatening, many pitched in and helped collect (especially the children, who thought it was all great fun, and were a tremendous help). The local *colmado* (combined country store and bar), no



Text-figure 1. — Locality map for the sections measured and described by Saunders, Jung, and Biju-Duval (1986). The TU collections were made in these same areas but in intervening areas also. See Appendix 4 of that work for a complete description of all TU localities.

matter how far off the beaten track (for example, Potrero, which is many miles from the nearest pavement), always had *cold* drinks, thanks to butane refrigeration.

In all, the collecting in the Dominican Republic is the most fantastic I have ever had the pleasure to partake of, due to the large number of muricid gastropods that occur at most localities. In the Gurabo Formation, particularly, the faunas are primarily gastropods at almost all exposures; pelecypods are usually fractured and difficult to obtain. Corals abound throughout the section, and in places foraminifers, chiefly specimens of the genus *Amphistegina* d'Orbigny, 1826 (Text-fig. 2), form the total matrix in which the larger fossils are found.

ACKNOWLEDGMENTS

In a review of this magnitude, and one that has been in progress for over ten years, so very many individuals have in some way given assistance that it is impossible to thank them all. But certain of these must be singled out for a special measure of gratitude, and first among these would be the people of the Cibao Valley, in particular Vinicio Jaques, field assistant extraordinaire, Andres Jaques, and the children of Francisco Antonio Torre and Celesta Diaz, of Gurabo Adentro, who have grown up collecting fossils with us. In a more scientific vein, the late Axel A. Olsson is fondly remembered for having originally given me all of his muricid ma-

terial from the Dominican Republic, collected in trips subsequent to the original 1916 Maury Expedition. Wilburn H. Akers, formerly Paleontologist with Chevron USA, now retired, was most helpful, providing nannoplankton dating in the years before the dates of Saunders, Jung, and Biju-Duval (1986) were available. Eugenio de Jesus Marciano F., for some time Director of the Museo Nacional de Historia Natural, Santo Domingo, was most generous with specimens from his own extensive collections of Dominican fossils, as well as providing very useful locality information. Anthony D'Attilio and the late George E. Radwin, of the San Diego Natural History Museum, gave permission (posthumously, in part) to quote their descriptions of Recent species and provided many less tangible instances of help over the years of worrying over muricid problems.

To Peter Jung and John Saunders, who collected much of the material utilized in this study, mere words scarcely suffice; the study would have been much the poorer without it. Colleagues at a number of institutions provided specimens on loan, copies of literature, maps, and general information, as requested, including: the Academy of Natural Sciences, Philadelphia (Robert Robertson, Melanie Miller, Mary Garback, Elizabeth Scott), American Museum of Natural History (William K. Emerson), Australian Museum (Winston F. Ponder), British Museum (Natural History)



Text-figure 2. — Incredibly abundant specimens of *Amphistegina* d'Orbigny, 1826, in Maury's "Zone C" of the Gurabo Formation, just east of the Río Gurabo on Los Quemados-Sabaneta road (loc. TU 1369).

(Patrick Nuttall, John Taylor, Kathie Way, the late L. R. Cox), University of California, Berkeley (Liz Nesbitt, the late Joseph H. Peck), Instituto Geografica Universitaria, Santo Domingo (José Hungaria Morell, Orlando Adams), Museum of Comparative Zoology, Harvard (Kenneth J. Boss), National Museum of Wales, Cardiff (P. Graham Oliver), Paleontological Research Institution, Ithaca, New York (the late Katherine V. W. Palmer, Peter R. Hoover), and the United States National Museum of Natural History (Warren Blow, M. G. Harasewych, Silvard P. Kool, the late Joseph Rosewater, Thomas R. Waller, Druid Wilson). In addition, Dieter Cosman, J. Gibson-Smith, Pierre Lozouet, David Robinson, and Danker Vink either loaned or donated specimens from their personal collections.

Finally the deepest appreciation must be expressed to my husband, Harold E. Vokes, field assistant, preparator, traveling companion, sympathetic listener, and all-round co-worker.

BIOSTRATIGRAPHY

Most of the basic geologic knowledge of the Dominican Republic dates back to Gabb (1873), who considered all of the Neogene beds as one Miocene formation. Maury (1917, 1919) divided the "Miocene" of Gabb into several formations in the Cibao valley region — that is, the valley of the Río Yaque del Norte. Cooke (in Vaughan *et al.*, 1921) further defined formations in both the Cibao and the southern Azua-San Juan valley (the Río Yaque del Sur).

Originally the beds of the Yaque Group were ascribed to the Oligocene and Miocene, the Cercado and Gurabo formations being early and middle Miocene respectively. However, this was done on the basis of molluscan similarities with other Caribbean formations, all of which are proving to be younger than originally thought (see Saunders, Jung, and Bijou-Duval, 1986, table 1).

Bermúdez (1949) and Bold (1968) published paleontological studies of the smaller foraminifers and ostracodes, respectively, using material and information provided by Dohm and Bell, who collected samples for micropaleontological studies in the years 1940–1943. The stratigraphy presented in both these works is essentially the same as that of Cooke and Maury, although Bermúdez divided the southern "Yaque Group" into several formations, which are not recognized herein.

In a more recent paper, Dorreen (1979) attempted to refine the ages of certain of the formations in the Dominican Republic on the basis of planktic foraminifers. Unfortunately, none of the samples discussed have sufficiently accurate locality data for precise placement stratigraphically. The only unit of interest

for my study is the sample of "Mao Formation" said to be from "SW of Santiago." The age cited is N.17¹, and probably applies to an outcrop of the Gurabo Formation rather than the Mao.

This study does not include every Neogene formation from the Dominican Republic. In general, the beds of the so-called "Yaque Group" in the southern portion of the Republic are not rewarding for molluscan collecting. The fossil muricids are poorly preserved but, when identifications are possible, in every case they are the same as those of the northern Yaque Group.

In the north the stratigraphy is better known because the fossils have been better studied. Thus, we see at the base of the Yaque Group the Baitoa Formation. The age of the Baitoa Formation has been debated for many years and I once (Vokes, 1979) attempted to determine the exact age on the basis of mollusks, for at that time there were no other guide fossils. In that study I concluded that the Baitoa Formation is of Burdigalian (late early Miocene) age, a conclusion reinforced by additional Burdigalian muricids collected subsequently.

The Baitoa Formation outcrops only in the immediate vicinity of the type locality and there it rests unconformably on the upturned beds of the Oligocene (N.3) Tabera Formation. Elsewhere the basal unit of the Yaque Group is the unfossiliferous Bulla Conglomerate.

Although Bermúdez (1949, p. 13) considered the Baitoa Formation and the Bulla Conglomerate as lateral equivalents, this does not seem to be the case. Both conglomerates do occupy the same position — in its type area the Baitoa rests on the upturned beds of the Tabera Formation, and in the vicinity of Jánico (no more than 12 km to the west of Baitoa) the Bulla Conglomerate does also. But here the Bulla can be seen to be the basal conglomerate, grading into the Cercado Formation, in a series of road cuts about 5 km north of Jánico (Text-fig. 3).

¹ Saunders, Jung, and Bijou-Duval (1986) indicate the ages of the various strata in two ways: one is by planktic foraminifers (*e.g.*, *Globorotalia margaritae*), a zonation originally proposed by Blow (1969); the second is by calcareous nannoplankton (*e.g.*, NN 16), as originally proposed by Martini (1971). In this paper I have followed the scheme utilized by most workers in the American Cenozoic (see Bold, 1988, for example) citing the Blow planktic zones as N. (for Neogene) zones. For ease of reference a rough correlation chart for the Neogene sequence would be:

age	N. zone	NN zone
Quaternary	N.22, N.23	NN19–NN21
late Pliocene	N.21	NN16–NN18
early Pliocene	N.18–N.20	NN12–NN15
late Miocene	N.15–N.18	NN10–NN12
middle Miocene	N.9–N.15	NN6–NN9
early Miocene	N.4–N.8	NN1–NN5

The main reason for not accepting the correlation is the total difference in composition of the molluscan fauna between the Baitoa Formation and the equally shallow-water Cercado Formation (at loc. TU 1230, for example, where the shells are intermingled with gravel in a facies that appears little different from that of the Baitoa Formation). The facies are so nearly the same that there must be a considerable age difference between the two units for them to have such completely different molluscan faunas. On the basis of the ostracodes, Bold (1988, p. 11) has dated the Baitoa Formation as N.7-10, or late early Miocene to early middle Miocene, which agrees with the planktic foraminiferal dating given by Saunders, Jung, and Biju-Duval (1986, p. 10).

The areal extent of the Baitoa Formation is extremely limited, covering no more than 2 km². This limited extent suggests that the outcrop occupies the northern portion of a fault-block that has been tilted down to the north by the "Tavera Fault" of Palmer (1979, p. 64; map). Palmer notes that the beds of the Tabera Group on the north side of the fault are steeply tilted, as is verified by Saunders, Jung, and Biju-Duval (1986, p. 24). The beds of the Baitoa Formation are also dipping more steeply than just depositional angle would give, being approximately 10° to the north. It is assumed that because of the Tabera Fault and the tilting of the strata, the small area of Baitoa Formation

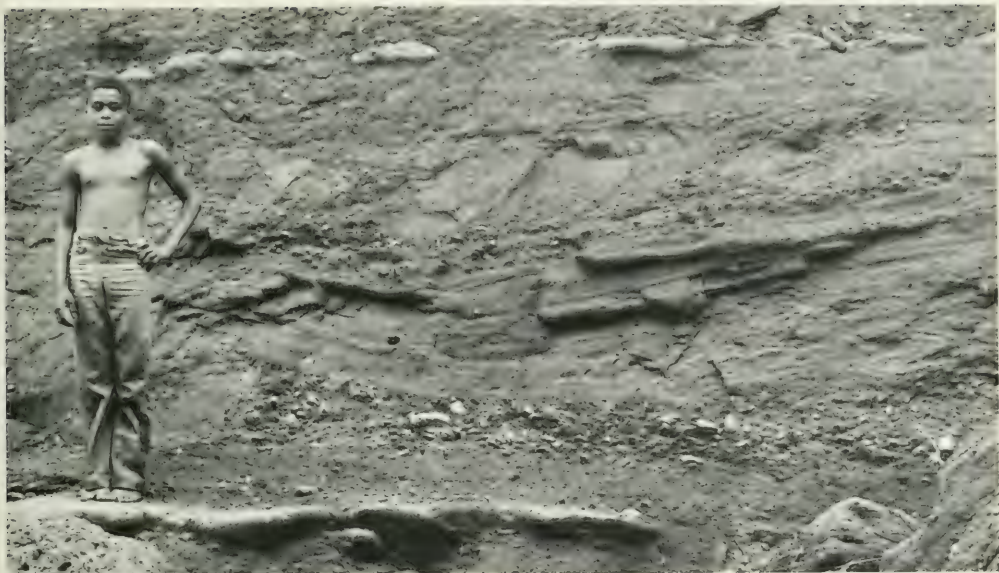
was somehow protected from the mid-Miocene erosion that removed the beds everywhere else before the deposition of the Bulla Conglomerate.

In southeastern Haiti, the Thomonde Formation (see Woodring, Brown, and Burbank, 1924, p. 165) is of approximately the same age as the Baitoa Formation and carries a similar fauna. One assumes that during Baitoa time there was an "ancestral" Hispaniola, which consisted of the present-day Cordillera Central, with Baitoa on the northern shoreline and Thomonde the southern. The areal extent of the Thomonde Formation is much greater than that of the Baitoa Formation and from it one is able to get a better picture of molluscan diversity during the early Miocene.

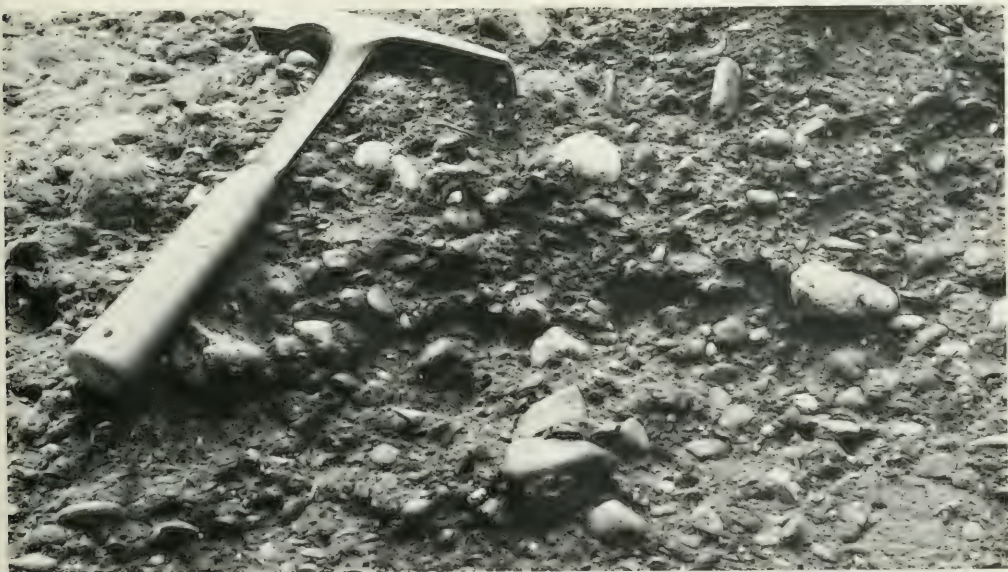
On the south side of the valley of the Río Yaque del Norte, the youngest beds exposed are a strange mélange of slumped and contorted sands, gravels, and large blocks of semi-indurated shales, which seem to represent large scale submarine landslides that may have been triggered by earthquakes signaling the uplift of the island to its present elevation. These beds were referred to an unnamed upper member of the Mao Formation by Bermúdez (1949, p. 15), and are well developed along the lower stretches of the Río Gurabo just above Gurabo Afuero (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 13) where shallow-water mollusks, gravel and sand have been brought down into a deep-water environment (Text-figs. 4 and 5).



Text-figure 3 -- Bulla Conglomerate grading upward into sands of the Cercado Formation, on Santiago de los Caballeros-Jánico road (loc. TU 1340).



Text-figure 4.—Gravity slumping, with lenses of coarse material in deep-water clays of the upper member of the Mao Formation; Río Gurabo, upstream from Gurabo Afuero (loc. TU 1352).



Text-figure 5.—Closeup of "pebbly mudstone" gravity flow into the deep-water clays of the upper member of the Mao Formation; Río Gurabo, upstream from Gurabo Afuero (loc. TU 1352).

Below these chaotic beds are the more normal deep-water clays of the Mao Clay Member of the Mao Formation. At the type locality near Mao (loc. TU 1337; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 29) these have been dated by Seiglie and Cucurullo (1971) as N.19, as N.20 by Akers (oral commun., 1980), and as NN16 (= N.21) by Saunders, Jung, and Biju-Duval (1986). Lithologically the Mao Clay is indistinguishable from the upper parts of the Gurabo Formation, but the fauna indicates deposition in much deeper water.

The Mao Adentro Limestone Member is the basal part of the Mao Formation and consists of a series of interlayered coral beds and clay. At the type locality of the Mao Adentro Limestone (loc. TU 1336; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 15) it can clearly be seen that the coral layers represent gravity flows into the blue clays of the Mao Formation. The corals are not in place but are jumbled breccias bounded above and below by clay that is identical lithologically and faunally to the type Mao Clay; according to Akers the age of the clay at both places is N.20. Cooke (*in* Vaughan *et al.*, 1921, p. 73) noted five limestone ledges and five shale beds within 8 m (vertically) at Mao Adentro.

Where the Mao-Sabaneta road crosses the Samba Hills ridge, about 4 km east of Los Quemados (loc. TU 1208), road work in 1981 exposed a magnificent sec-

tion of the Mao Adentro Limestone. The type locality is somewhat difficult of access but this roadcut (Text-figs. 6, 7) shows the nature of the Mao Adentro extremely well and might be taken as an alternative type locality. It is approximately 5.5 km (airline) west of the type locality (loc. TU 1336) on the Río Mao.

Overlying the Baitoa Formation (unconformably) and the Bulla Conglomerate (gradationally) and underlying the Mao Formation are two faunal units that have been designated as the Cercado and Gurabo formations. They are, in fact, lateral facies-equivalents but they are certainly distinct lithologic units and as such are recognized here as valid "formations". However, in places it is possible to see gravity-flows of Cercado facies into the deeper-water Gurabo Formation. A good example of this is on the Río Verde near Cerro Santo, southeast of Santiago (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 38). This is one of the few places, along with the nearby Arroyo Puñal, where Gabb actually mentions collecting fossils. At Río Verde (loc. TU 1250), there are several flows diagonally across the face of the bluff, containing a coquina of broken large mollusks and well-preserved smaller shells that most resembles the fauna at locality TU 1230, an exposure of Cercado Formation on the Río Cana, at Caimito (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 15). Here are numerous species of *Olividae*, *Semicassis reclusa* (Guppy, 1874), *Stigmaulax sulcatus*



Text-figure 6. —Gravity-flow beds of coral breccia in the Mao Adentro Member of the Mao Formation; roadcut where Mao-Los Quemados road crosses the Samba Hills (loc. TU 1208).



Text-figure 7.—Closeup of coral breccia layers; roadcut where Mao–Los Quemados road crosses the Samba Hills (loc. TU 1208).



Text-figure 8.—Río Gurabo, looking upstream from ford on Los Quemados–Sabaneta road, which crosses the river above Gurabo Adentro.

(Born, 1778), *Murex messorius* Sowerby, 1841a, as well as *Aphera islacolonis* (Maury, 1917), the so-called "guide fossil" to the Cercado Formation.

At Arroyo Puñal (loc. TU 1353; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 37), on the basis of the presence of certain planktic foraminifers, the beds are estimated to have been deposited in comparatively deep water, more than 100 m. As with the Río Verde the mollusks have been carried by gravity-flows into blue clays that are basically barren of mollusks and that, in every respect except age, resemble the Mao Clay. One could make the case that the very deep-water Gurabo Formation exposures in the vicinity of Santiago should be called "Mao Clay" as they were mapped by Dohm (*in* Bold, 1968, text-fig. 6).

The type locality of the Gurabo Formation is on the Río Gurabo, both north and south of the crossing of the road from Los Quemados to Sabaneta. Today a high-level concrete bridge is planned, which will replace the old ford (for a time there was a low-level concrete bridge, until it washed out in 1980), approximately one-half km above the ford. The old crossing is still visible and is used as a path to the river for cattle (Text-fig. 8). The old trail to what is called "Gurabo Adentro" on the USGS map (Vaughan *et al.*, 1921, pl. 11) is now utilized as access to the numerous small farms that dot the area.

Although the stratigraphy of the Cibao Valley has now been definitively established by the NMB work (Saunders, Jung, and Biju-Duval, 1986), when we began our work in 1976 the only reference we had available was Maury (1917). Thus, we based our collecting localities and our understanding of the stratigraphy upon her data. Even if it is now of no more than historic interest, it seems relevant to this study to examine her concept of the stratigraphy.

Maury zoned the Gurabo outcrop from "A" to "F", proceeding in an upstream direction. As she noted (1917, p. 433): "Actual superposition does not exist. The section is made up from successive bluffs met with on ascending the river." Her Zone A includes our localities TU 1214, 1213, 1212, and 1210 (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5) in descending stratigraphic order. Locality TU 1210 is the principal bluff on the Gurabo, that one just below the highway crossing (Text-fig. 9; Saunders, Jung, and Biju-Duval, 1986, pl. 2, fig. 1). Maury's Zone B is the bluff below the second ford (loc. TU 1211; see Saunders, Jung, and Biju-Duval, 1986, pl. 2, fig. 2), which because of the large northward bend in the river is actually farther down-section than is the more upriver first bluff (loc. TU 1210). At locality TU 1211 there are limy lenses (Text-fig. 10) just above river level with a fauna that indicates slightly shallower conditions than those in



Text-figure 9 – Bluff on east side of Río Gurabo, downstream from the ford on Los Quemados–Sabaneta road (loc. TU 1210; Maury's Zone A).



Text-figure 10. — *Amphistegina*-rich limestone lenses, bluff below second ford, Río Gurabo at Gurabo Adentro (loc. TU 1211; Maury's Zone B).



Text-figure 11. — Alternating beds of coral and shale, east side of Río Gurabo above the ford on the Los Quemados–Sabaneta road (loc. TU 1215; Maury's Zone D).

the stratigraphically-higher as well as deeper-water locality TU 1210. At locality TU 1210, the only corals are large solitary forms; foraminifers, although present, are not seen until the matrix is washed. At locality TU 1211 the corals are branching colonial forms, and specimens of *Amphistegina* d'Orbigny, 1826, form conspicuous lenses. The molluscan fauna at the two localities differs principally in the numbers of individuals of various species. It is at locality TU 1210 that Saunders, Jung, and Biju-Duval (1986, p. 16) also note a marked deepening of the paleo water-depth, which they attribute to a world-wide rise in sea level.

Maury's Zone C is well exposed in the road-cuts leading down to the first ford from the east (loc. TU 1279; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5). Zone D begins about 0.75 km above the ford and is locality TU 1215 (Text-fig. 11; see Saunders, Jung, and Biju-Duval, 1986, text-figs. 5, 10; pl. 2, figs. 3, 4). This outcrop consists of alternating layers of branching coral masses (Text-fig. 12) and greenish shale. Here are several species that occur nowhere else along the Río Gurabo, including: *Chicoreus* (*Naquetia*) *compactus* (Gabb, 1873); *Muricopsis praeapauxillus* (Maury, 1917); *Pterynotus* (*Purpurellus*) *mirificus*, n. sp.; *Lyria incompta* Hoerle and Vokes, 1978; *Coralliophila abbreviata* (Lamarck, 1816) [= *C. miocenica* of Maury (1917), not of Guppy (1873)]; and *C. caribaea* Abbott, 1958, to cite a few. To give an idea of the richness of

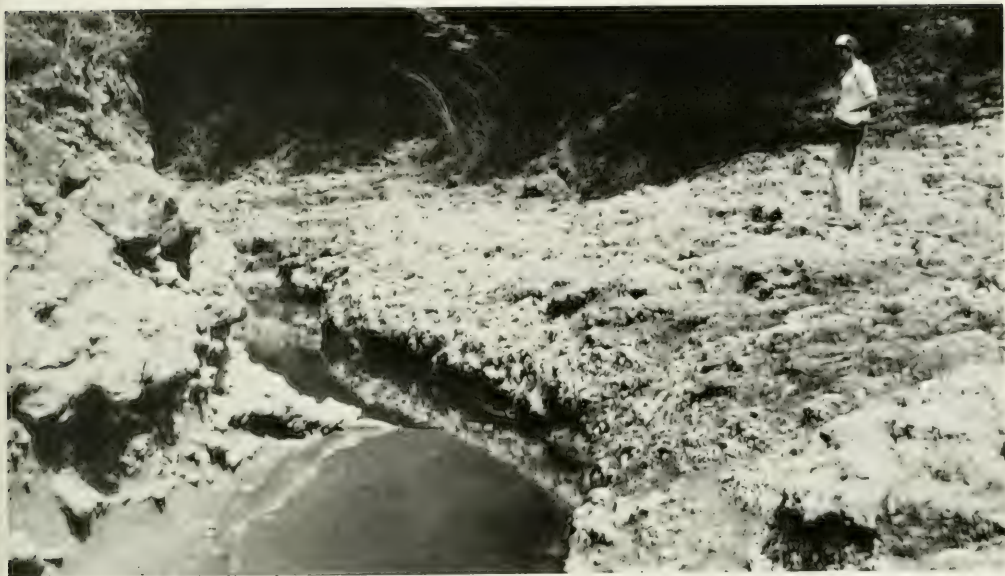
the fauna at locality TU 1215, 25 of the 44 muricid species known from the Gurabo Formation have been collected here. It is the type locality of 10 species of muricids.

This coral-reef fauna is confined to the true reef localities, which, in addition to locality TU 1215, are Cañada de Zamba (loc. TU 1354; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 15), a tributary of the Río Cana below Caimito, and the most spectacular reef of all, that one on Arroyo Bellaco (loc. TU 1422; Text-fig. 13). This reef is exposed for approximately 1 km along the course of Arroyo Bellaco, which enters the Río Cana above Caimito. It was discovered by Professor Eugenio Marciano F., formerly of the Museo Nacional de Historia Natural, Santo Domingo, and discussed by him in his work on the Cercado Formation (Marciano F., 1981, pp. 20ff), wherein he notes that the reef attains thicknesses of up to 10 m.

The only other place where this peculiar reef-facies fauna occurs is a most unusual locality, TU 1227A (Text-fig. 14). This locality is in Arroyo Zalaya (loc. TU 1227; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36), a narrow canyon cut into a deeper-water facies of the Gurabo beds, as indicated by the presence of *Chicoreus* (*Siratus*) *yaquensis* (Maury, 1917) and *Poirieria* (*Paziella*) *dominicensis* (Gabb, 1873). But in the midst of it there is a gravity-flow lens about 25 cm (10 in) thick, extending no more than 1 m laterally,



Text-figure 12.—Top view of branching corals, east side of Río Gurabo above the ford on the Los Quemados-Sabaneta road (loc. TU 1215).



Text-figure 13.—Coral reef on Arroyo Bellaco, at Las Caobas Adentro (loc. TU 1422).



Text-figure 14.—Gravity-flow lens in the deep-water Gurabo Formation at Arroyo Zalaya, south of Santiago de los Caballeros (loc. TU 1227A).

Table 1.—Numbers of specimens of the four most abundant muricine species at selected localities in the Gurabo Formation. (For locality maps, see Saunders, Jung, and Biju-Duval, 1986, text-figs. 5, 34.)

	Río Amina (loc. TU 1219)	Río Gurabo above the bridge (locs. TU 1215, 1246, 1277, 1296)	Río Gurabo below the bridge (locs. TU 1210–1214)
<i>Murex (Haustellum) messorius</i>	137	42	9
<i>Murex (Haustellum) pennae</i>	140	21	11
<i>Chicoreus (Chicoreus) cornupectus</i>	40	105	23
<i>Chicoreus (Siratus) domingensis</i>	134	14	818

which is a coquina of small mollusks, foraminifers, and calcareous detritus. The fauna is that of Maury's Zone D, with *Murex (Haustellum) messorius* Sowerby, 1841a, *Muricopsis praepauxillus* (Maury, 1917), and abundant cerithiids. This intrusion of a shallow coralline assemblage into the deepest Gurabo Formation is fascinating to behold.

Maury's Zone E is about 1 to 2 km above the ford and is our locality TU 1246 (see Saunders, Jung, and Biju-Duval, 1986, fig. 5). Maury's Zone F is the basal beds of the Gurabo Formation and includes our localities TU 1277 and 1296 (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5), extending from the horse-trail upstream to the "contact" with the Cercado Formation. The fauna of Zone F is best developed at the Potrero ford on the Río Amina (loc. TU 1219; see Saunders, Jung, and Biju-Duval, 1986, text-figs. 34, 35).

In terms of muricid fauna, the break between Zones A/B and D, or below and above the bridge, is very obvious. Table 1 shows the distribution of the four most common muricine species along the Río Gurabo, with the Río Amina for comparison.

On the Río Mao a sequence identical to that on the Río Gurabo may be observed. Working downstream from Bulla, where the Bulla Conglomerate appears, one goes first into the very shallow-water Cercado Formation at "Bluff 3" (loc. TU 1294; see Saunders, Jung, and Biju-Duval, 1986, text-figs. 29, 33; pl. 8, figs. 1, 2), through the "modified Cercado" of Vaughan *et al.* (1921) at "Bluff 2" into the intermediate-depth Gurabo Formation at "Bluff 1" (loc. TU 1293; see Saunders, Jung, and Biju-Duval, 1986, text-figs. 29, 33; pl. 8, figs. 1, 2), and finally just above Mao Adentro, in the last exposures of the Gurabo Formation, the deepest beds of all (loc. TU 1292; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 29), with a fauna most like that of locality TU 1227 (see Table 3).

As Maury noted (1917, p. 439),

No line of contact could be found between G [= Cercado Formation] and F [= Gurabo Formation] nor any sign of unconformity but even in the field the fauna of G appeared markedly different from the faunas of the preceding zones

Gurabo formations are really faunal zones, as Woodring (1965, p. 962) observed, representing the very shallow and the deeper-water facies, respectively. However, they are distinctive lithologically and by this definition are valid formations.

On the Río Gurabo, approximately 4 km upstream from the ford on the Los Quemados-Sabaneta road, there is a large westward loop in the river, which is conspicuous on a topographic map. At this point (locs. NMB 16181, 16182 = loc. USGS 8738; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5) there occurs in the section a most unusual conglomerate layer. Saunders, Jung, and Biju-Duval (1986, p. 12; text-fig. 9; pl. 1, figs. 1–3) interpret this as the contact between the Cercado and the Gurabo formations, but there is one flaw in this interpretation. In the beds above this "contact" the lithology and fauna are identical to those below it and to every visible aspect still must be called "Cercado Formation". The change from a Cercado to a Gurabo lithology occurs at a bed of *Amphistegina*- and *Pecten*-rich sand, about 3 km above the ford (the line between locs. TU 1297 and 1296; Maury's Zones G and F). The beds of locality TU 1297 (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5, pl. 2, fig. 5) between the conglomerate and the *Amphistegina*-sand are a fine sand with a shallow-water mollusk fauna identical to that of the other Cercado Formation localities, including the large "typical" Cercado Formation concretions; but at locality TU 1296, immediately overlying these, one sees an almost complete change of fauna as well as a change to the fine gray silty clay of the Gurabo Formation.

The conglomerate bed (Text-fig. 15) is, instead, a beautiful example of what Walker (1975, p. 743) has termed the "graded-stratified" model of a "resedimented conglomerate". The geologic implication of this sequence, which has at the base a crudely stratified cobble conglomerate grading upward into a fairly well-stratified, shell-bearing, sandy layer, is deposition by a rapid, high-turbulence gravity-flow down the steep slope of a submarine canyon. According to Walker's diagram (1975, p. 746, fig. 10), the locality under consideration would be very near the mouth of the canyon, but deep enough to be below wave base. Thus, the outcrop should be interpreted as an *intra*-formational

There seems little doubt that the so-called Cercado and

conglomerate not greatly different from the many other gravel lenses in the Cercado Formation. Certainly nowhere else is there any evidence of a break between the two units. Even on the Río Gurabo, just a short distance upstream, a coral bed can be seen to grade upward into a fine sand without any trace of a conglomerate layer.

Elsewhere the two units simply grade from one into the other laterally without any visible line of demarcation and it is difficult to say exactly where the boundary between the two should be drawn. However, the faunas in general are completely distinctive and can be separated at a glance. Therefore, in this paper the names "Cercado Formation" and "Gurabo Formation" will be maintained, even though the terms may be more of historical than of stratigraphic interest.

The section along the Río Yaque del Norte is somewhat different from that along the other rivers to the west. At Baitoa the beds of the Baitoa Formation are in angular unconformity upon the strongly-tilted Oligocene Tabera Formation (see Vokes, 1979, fig. 2; also see Saunders, Jung, and Biju-Duval, 1986, text-fig. 28). At the type locality of the Baitoa Formation, on the bend of the Río Yaque just below the village of Baitoa, the formation is found at the top of the bluff approximately 50 m above river level. Less than 0.5 km to the north, at Boca de los Ríos, the Baitoa Formation

is at river level, indicating a 10° northward dip to the beds (see Saunders, Jung, and Biju-Duval, 1986, pl. 9). The contact between the Baitoa Formation and overlying beds is not exposed in the river but must occur in the interval between Boca de los Ríos and the village of López, for here at river level we find exposures of a shallow-water reefal facies unlike the underlying Baitoa Formation. At López there is a series of hard limestone beds, the lowest one making an extensive platform at river level (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 26, pl. 8, fig. 5) with the surface showing numerous large mollusks, such as *Amusium papyraceum* (Gabb, 1873) and *Ostrea haitensis* Sowerby, 1850, and large clypeasteroid echinoderms.

Although the contact between the Baitoa Formation and the younger beds cannot be seen on the river, it was well exposed for a time in new (1983) roadcuts on the highway leading down into Baitoa from Santiago. Here there is a thick series of Baitoa conglomerates extending up almost to the crest of the hill. At the top of the Baitoa beds there is an old soil zone topped by a relatively level erosional contact (Text-fig. 16), which is overlain immediately by coralline beds that I attribute to the Gurabo Formation, but which may be the equivalent of the López section.

Below López the Río Yaque makes a large westward loop before entering the mouth of the Angostura gorge



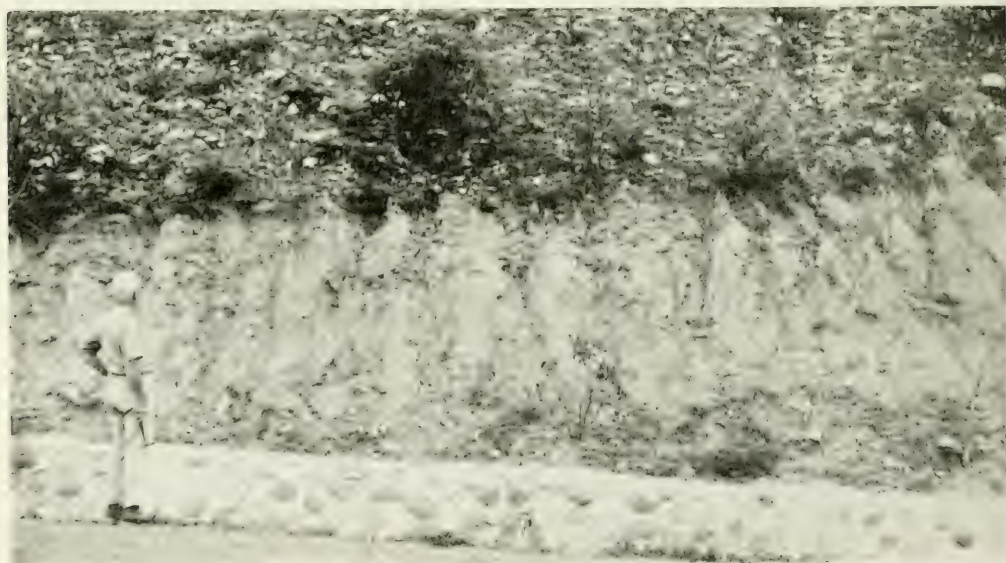
Text-figure 15.—"Graded-stratified" conglomerate in upper part of the Cercado Formation; west side of Río Gurabo, approximately 4 km above the ford on Los Quemados-Sabaneta road (loc. TU 1418).

(see Saunders, Jung, and Biju-Duval, 1986, text-fig. 23), which is cut in a thick coral reef approximately 2 km across (along the river) and at least 140 m in thickness. This canyon has until recently been more or less inaccessible except by boat, but work on the López-Angostura hydroelectric project in 1982–1983 opened up three access roads into this canyon from the east side, and, at the same time, created marvelous exposures for the entire section. That road upstream from the Angostura canyon leading to “La Ventana” tunnel exposed a most interesting section. Here, on the west bank of the river, there is a series of alternating coralliferous/algal limestones and gray silty beds that bear a molluscan fauna most like that at López. This area (locs. TU 1444–1447) was not investigated by the NMB team; therefore, a few words about the fauna are in order. The lowest locality in the section (loc. TU 1445) has elements that resemble both the Gurabo facies fauna [e.g., *Sconsia laevigata* (Sowerby, 1850), *Distorsio similimus* (Sowerby, 1850)] and the Cercado facies fauna [e.g., *Melongena consors* (Sowerby, 1850)], but there are also species that we have found nowhere else except at the Arroyo López outcrop farther upstream (e.g., *Cerithium turriculum* Gabb, 1873). As one goes up in the section the facies becomes increasingly shallow, so that locality TU 1447, which is about 20 m above river level on the access road and stratigraphically as much as 50 m above locality TU 1445, is the site of a number of unique species, all of which indicate

very shallow or even brackish water. These include numerous specimens (13 in all) of *Melongena orthocantha* Pilsbry and Johnson, 1917 (see Pilsbry, 1922, pl. 28, figs. 13–16); and rare examples of *Potamides prismaticus* (Gabb, 1873) (see Pilsbry, 1922, pl. 29, fig. 12) and *Terebralia dentilabris* (Gabb, 1873) (see Pilsbry, 1922, pl. 29, figs. 6, 7). In addition, there are several specimens of *Neritina virginea* (Linné, 1758), which also occurs rarely in the Cercado Formation (loc. TU 1419).

Given the regional strike (which is north-northwest), it seems probable that the beds at “La Ventana” are almost the exact stratigraphic equivalent of the beds exposed upstream from the mouth of Arroyo López (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 21). If one compares the sections given in Saunders, Jung, and Biju-Duval, 1986, text-figures 26 (the section at Arroyo López) and 27 (the section downstream from “La Ventana”), it seems highly probable that the uppermost beds at Arroyo López (beds H and I of the figure) are the same as the lowermost beds at the south end of the Angostura Gorge (loc. NMB 17318).

Bold (1988, table 4) has studied the material from this area and concluded that the age is the same as that of the upper Cercado Formation along the Río Gurabo section. Because the facies seems to be intermediate between that of the typical sandy Cercado Formation and the typical silty Gurabo Formation, there is some problem with using either of these names for the sec-



Text-figure 16. —Contact between Baitoa Formation and overlying coralline Gurabo (?) Formation, roadcut about 2 km north of Baitoa.

tion. To distinguish these beds I am herein referring them to an "unnamed formation", to signify the ambiguity present.

To the north of the Angostura reef (downstream) at river level, the beds of the typical deep-water Gurabo Formation begin and continue all the way to Santiago. In the vicinity of La Barranca and along Arroyo Babosico, which enters the Río Yaque del Norte from the west about 8 km upstream from Santiago (locs. TU 1403, 1404, 1405), there are a series of shallow-water gravity flows that once again bring shallow-water fossils into the very deep facies of the Gurabo Formation. One of these is particularly well-exposed on the road that goes down to the river at La Barranca (Text-fig. 17). Here (loc. TU 1449) again we see a typical Cercado fauna, with *Stigmaulax sulcatus* (Born, 1778), *Aphera islacolonis* (Maury, 1917), several species of Olividae and other shallow-water species, in beds that on the basis of planktic foraminifers must have been deposited in at least 200 m of water.

The muricid fauna of the Dominican Republic Neogene is amazingly rich. There is a representative of almost every subgeneric group present in the western Atlantic, plus some that were not previously known to occur (see Table 2).

PALEOECOLOGY

A total of 61 species of Muricidae (divided into 34

subgenera) have been identified from the beds of the Yaque Group. Of these the largest number, 42, are from the Gurabo Formation; only 20 come from the more shallow Cercado Formation and of these only six do not also occur in the Gurabo (five being shallow-water thaidines), which confirms our field observation that the Gurabo and the Cercado are only lateral facies of each other. The deep-water Mao Formation is normally devoid of muricids, but in a shallow-water gravity flow along the lower reaches of the Río Gurabo, there are eight muricid species, all but two of which also occur in the Recent fauna. The shallow-water Baítoa Formation has only 10 species.

On the basis of comparison of depth ranges of the living counterparts of the various species we can say that the Cercado Formation was probably deposited in water depths of 0 to 20 m, and the shallow-water portions of the Gurabo Formation, including the coralline facies (locs. TU 1215, 1354; see Saunders, Jung, and Biju-Duval, 1986, text-figs. 5, 15) in depths of about 20 to 50 m. The moderately deep portions of the Gurabo Formation, such as at the type locality along the Río Gurabo (locs. TU 1210–1214; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5), were deposited in 50 to 150 m, and the very deep portions, such as Arroyo Zalaya (loc. TU 1227; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36) in 150 to 350 m.



Text-figure 17.—Gravity flow of shallow-water material into very deep-water Gurabo Formation, road leading down to Río Yaque del Norte at La Barranca (loc. TU 1449).

Table 2.—Fossil muricid species recognized in the Neogene of the Dominican Republic.

species	Baitoa Formation	Cercado Formation	Gurabo Formation	Mao Formation	Recent
Family Muricidae					
Subfamily Muricinae					
<i>Murex (Haustellum) messorius</i> Sowerby	+	+	+	+	+
<i>Murex (Haustellum) pennae</i> Maury	—	+	+	—	—
<i>Murex</i> (? <i>Haustellum</i>) <i>adelosus</i> , n. sp.	—	+	+	—	—
<i>Chicoreus (Chicoreus) cornurectus</i> (Guppy)	+	+	+	—	—
<i>Chicoreus (Chicoreus) dujardinioides</i> (Vokes)	—	—	—	—	—
<i>Chicoreus (Chicoreus) corrigendum</i> , n. sp.	+	—	—	—	—
<i>Chicoreus (Chicoreus) cosmani</i> Abbott and Finlay	—	—	+	—	+
<i>Chicoreus (Chicoreus) sp.</i> cf. <i>C. (C.) clausii</i> (Dunker)	—	—	—	+	+
<i>Chicoreus (Chicoreus) enigmaticus</i> , n. sp.	—	+	—	—	—
<i>Chicoreus (Phyllonotus) infrequens</i> (Vokes)	+	—	—	—	—
<i>Chicoreus (Phyllonotus) pomatus</i> , n. sp.	—	+	+	—	—
<i>Chicoreus (Phyllonotus) pomum</i> (Gmelin)	—	—	—	+	+
<i>Chicoreus (Naquetia) compactus</i> (Gabb)	—	+	+	—	—
<i>Chicoreus (Siratus) domingensis</i> (Sowerby)	—	—	+	—	—
<i>Chicoreus (Siratus) articulatus</i> (Reeve)	—	—	—	+	+
<i>Chicoreus (Siratus) formosus</i> (Sowerby)	—	—	—	+	+
<i>Chicoreus (Siratus) amplius</i> , n. sp.	—	—	+	—	—
<i>Chicoreus (Siratus) yaquensis</i> (Maury)	—	—	—	—	—
<i>Chicoreus (Siratus) eumekes</i> , n. sp.	—	—	+	—	—
<i>Pterynotus (Pterynotus) phyllopterus</i> (Lamarck)	—	—	+	—	+
<i>Pterynotus (Pterynotus) aliculus</i> , n. sp.	—	—	+	—	—
<i>Pterynotus (Pterynotus) neotripteris</i> , n. sp.	—	—	+	—	—
<i>Pterynotus (Purpurellus) mirificus</i> , n. sp.	—	—	+	—	—
<i>Poirieria (Paziella) dominicensis</i> (Gabb)	—	—	+	—	—
<i>Poirieria (Panamurex) gabbii</i> Vokes	—	—	+	—	—
<i>Poirieria (Flexopteron) collata</i> (Guppy)	—	—	+	+	—
<i>Aspella castor</i> Radwin and D'Attilio	—	—	+	—	+
<i>Dermomurex (Dermomurex) olssoni</i> , n. sp.	—	—	+	—	—
<i>Dermomurex (Dermomurex) granulatus</i> , n. sp.	—	—	+	—	—
<i>Dermomurex (Dermomurex) cracentis</i> , n. sp.	—	—	+	—	—
<i>Dermomurex (Triatella) pteryonoides</i> , n. sp.	—	+	+	—	—
<i>Attiliosa aldridgei</i> (Nowell-Usticke)	—	+	+	—	+

On the basis of the molluscan fauna, it is obvious that the Baitoa Formation was deposited very near to the shoreline, deepening to perhaps as much as 20 m. In contrast, the Mao Formation is the deepest material in the entire section, representing continental-slope deposits of at least 350 m. However, locally, gravity flows have brought in material from much lesser depths to be mixed with the deep-water sediments.

If one excludes the seven species that, in the Dominican Republic, are confined to the Baitoa Formation, and looks only at the younger forms, there are some interesting relationships with the Recent fauna. Not surprisingly, 56% (31 of 55) have identical or very closely related forms in the Recent fauna of the western Atlantic and, in some cases, the eastern Pacific; however, three of these now occur only in South America: *Chicoreus (Siratus) amplius*, n. sp.; *Urosalpinx denticulatus*, n. sp.; and *Thais (Thaisella) trinitatis* (Guppy, 1869). Another three species have their closest relative in the eastern Atlantic, off the western coast of Africa.

What is more remarkable is that 16% (nine of 55) have their only near relatives in the Indo-West Pacific, with no close relatives in either the western Atlantic or the eastern Pacific. Some of these doubtless represent parallel evolution from a common ancestor far back in the early Tertiary Tethyan Sea [e.g., *Pterynotus (Pterynotus) neotripteris*, n. sp.], some may represent convergence [e.g., *Chicoreus (Naquetia) compactus* (Gabb, 1873)], but for some there is simply no explanation for the disjunct distribution. Principally, what we see in this large percentage of forms that no longer have any representation in the New World is the great loss our molluscan fauna suffered as a result of Pleistocene glaciation.

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

Working with fossil molluscan remains forces one to take a totally morphological approach in dealing with the criteria of species differentiation. Fortunately, when working with forms that are as closely related in

Table 2.—Continued.

species	Baitoa Formation	Cercado Formation	Gurabo Formation	Mao Formation	Recent
Subfamily Muricopsinae					
<i>Murexiella</i> (<i>Murexiella</i>) <i>hidalgoi</i> (Crosse)	—	—	+	—	+
<i>Murexiella</i> (<i>Murexiella</i>) <i>magintyi</i> (Smith)	—	+	+	—	—
<i>Murexiella</i> (<i>Subpterynotus</i>) <i>textilis</i> (Gabb)	+	—	—	—	—
<i>Homalocantha</i> sp.	—	—	—	—	—
<i>Muricopsis</i> <i>praepauillus</i> (Maury)	?	+	+	—	—
<i>Muricopsis</i> <i>quisqueyensis</i> , n. sp.	—	—	+	—	—
<i>Murexsul</i> <i>mimicus</i> , n. sp.	—	—	+	—	—
<i>Favartia</i> (<i>Favartia</i>) sp.	—	+	+	—	—
<i>Favartia</i> (<i>Favartia</i>) <i>zalaya</i> , n. sp.	—	—	+	—	—
<i>Favartia</i> (? <i>Pygmaepterys</i>) <i>germainae</i> (Vokes and D'Attilio)	—	+	+	—	+
<i>Acanthotrophon</i> <i>striatus</i> (Gabb)	—	—	+	—	—
Subfamily Typhinae					
<i>Typhis</i> (<i>Typhinellus</i>) <i>sowerbii</i> Broderip	—	+	+	—	+
<i>Typhis</i> (<i>Talityphis</i>) <i>obesus</i> Gabb	+	—	—	—	—
<i>Typhis</i> (<i>Talityphis</i>) <i>alatus</i> Sowerby	—	—	+	—	—
<i>Typhis</i> (<i>Talityphis</i>) <i>expansus</i> Sowerby	—	—	—	+	+
<i>Siphonochelus</i> (<i>Siphonochelus</i>) <i>cercadicus</i> (Maury)	—	—	+	+	—
<i>Siphonochelus</i> (<i>Laevityphis</i>) <i>apehes</i> , n. sp.	+	—	—	—	—
<i>Siphonochelus</i> (<i>Laevityphis</i>) <i>spinirectus</i> , n. sp.	—	—	+	—	—
<i>Pterotyphis</i> (<i>Pterotyphis</i>) <i>pinnatus</i> (Broderip)	—	—	+	—	+
<i>Pterotyphis</i> (<i>Tripterytyphis</i>) <i>triangularis</i> (Adams)	—	—	+	—	+
Subfamily Thaidinae					
<i>Thais</i> (<i>Thaisella</i>) <i>trinitatensis</i> (Guppy)	—	+	—	—	+
<i>Thais</i> (<i>Thaisella</i>) <i>santodomingensis</i> Pilsbry and Johnson	—	?	—	—	—
<i>Thais</i> (<i>Stramonita</i>) <i>quadridentata</i> , n. sp.	—	+	—	—	—
<i>Spinidrupa</i> <i>radwini</i> , n. sp.	—	+	+	—	—
<i>Spinidrupa</i> <i>demissa</i> , n. sp.	—	—	+	—	—
<i>Urosalpinx</i> <i>denticulatus</i> , n. sp.	—	+	—	—	—
<i>Cymia</i> <i>henekeni</i> Maury	+	—	—	—	—
<i>Cymia</i> <i>marcanoi</i> , n. sp.	—	+	—	—	—
<i>Vitularia</i> <i>dominicana</i> Vokes	—	—	+	—	—
Total number of species:	10	20	42	8	17

time to the living members of the group as are the elements of the Neogene fauna of the Dominican Republic, there is little difficulty in recognizing similarities to descendent forms and concluding that the animals lived, reproduced, and died in the same manner.

Thus, the ecologic inferences, the taxonomic inferences, and the determinations of supra-specific groupings are all a reflection of the state of our knowledge of the living members of the Muricidae. Conclusions are limited more by the relatively poor degree of understanding of the living animals than by the problems of dealing with unoccupied "hard parts".

The synonymies are as straightforward as possible. All references that have been discovered in the literature are included, except for species that are also in the Recent fauna, where only significant references (*i.e.*, well-figured, stratigraphically or nomenclatorially relevant) are given. The terminology is equally straightforward. Terms such as "sp.", implying a specimen that may be identified as to genus but not to species, and "sp. cf.", implying a species that may be compared

to another similar but perhaps not identical species, should be familiar to all readers. The only terms that might be confusing are "non", which implies a senior homonym that preoccupies the taxon in question, *vs.* "not of", which refers to a misidentification by the author being cited. All references are given as shown in the original reference; however, a query in brackets [?] preceding the reference implies uncertainty on my part as to the validity of the identification by that worker.

Although this study is now a part of the Basel Naturhistorisches Museum Dominican Republic Project, it was not originally conceived as such. Initially the work was based upon the collections made by me and my husband; there was no "Tulane team" comparable to that of the Basel group. The bulk of the work was done before the Basel collections were curated and sent out for study. When the Basel material was made available, it was identified by locality number with only a brief notation (*e.g.*, "Río Gurabo", "Río Cana", "Río Mao", etc.) and no further geographic or stratigraphic infor-

mation. Therefore, the counts of specimens in Tables 1 and 3 are based only upon Tulane material; no attempt was made to include the Basel material. Addition of those specimens would have increased the numbers somewhat but would have made no other difference.

ABBREVIATIONS FOR REPOSITORIES

- ANSP: Academy of Natural Sciences, Philadelphia, PA, U. S. A.
 BMNH: British Museum (Natural History), London, England, U. K.
 CAS: California Academy of Sciences, San Francisco, CA, U. S. A.
 MCZ: Museum of Comparative Zoology, Harvard University, Cambridge, MA, U. S. A.
 MHNG: Muséum d'Histoire Naturelle, Geneva, Switzerland
 NMB: Naturhistorisches Museum, Basel, Switzerland
 PRI: Paleontological Research Institution, Ithaca, NY, U. S. A.
 TU: Tulane University, New Orleans, LA, U. S. A.
 UCMP: Museum of Paleontology, University of California, Berkeley, CA., U. S. A.
 USNM: United States National Museum of Natural History, Washington, DC, U. S. A.

SYSTEMATICS

Superfamily MURICACEA Rafinesque, 1815

Family MURICIDAE Rafinesque, 1815

Subfamily MURICINAE Rafinesque, 1815

Remarks.—Although the family Muricidae has been attributed to Costa, 1776, by several authors on the basis of the usage of Abbott (1974, p. 171), as Rehder pointed out (1980, p. 69) Costa's work is non-binominal and not available. The first available name, therefore, remains that of Rafinesque.

Genus MUREX Linné, 1758

Murex Linné, 1758, p. 746.

Type species.—*Murex tribulus* Linné, 1758, by subsequent designation, Montfort, 1810.

Subgenus HAUSTELLUM Schumacher, 1817

Haustellum Schumacher, 1817, p. 213.

Type species.—*Murex haustellum* Linné, 1758, by tautonymy.

Remarks.—The muricine species in the western Atlantic that have a long straight siphonal canal, such as *M. messorius* Sowerby, 1841a, almost invariably have been referred to *Murex* sensu stricto, but it now seems probable that the resemblance to that subgroup is due

only to convergence. During the time that this paper was in preparation I spent a sabbatical leave in Australia working with Dr. Winston Ponder of the Australian Museum on the Indo-Pacific species of *Murex* s. s. The major conclusion resulting from this study was that many species previously referred to *Murex* sensu stricto are not to be so assigned (see Ponder and Vokes, 1988).

In the Indo-Pacific region there are approximately 40 Recent species that have been referred to *Murex* (*Murex*) and(or) to *Haustellum*. Ponder and Vokes (1988) show that this number can be divided into two subgroups — those that have 12 (or more) rounded axial ribs on the first post-nuclear whorl, and those that have nine angulate to spinose varices on the first whorl. In the first group, every fourth rib ultimately becomes a varix; in the second, every third is enlarged to become a varix. In both cases there are three varices per whorl, but in the first there are initially three intervarical nodes, in the second two intervarical nodes.

Using these criteria alone, all of the species that generally have been referred to *Haustellum* (e.g.: *Haustellum wilsoni* D'Attilio and Old, 1971; *Murex tweedeanus* Macpherson, 1962; *Murex hirasei* Dautzenberg in Hirase, 1915; and *Murex haustellum* itself) are included, plus several species that heretofore have been considered *Murex* sensu stricto (e.g.: *Murex sobrinus* Adams, 1863, and *Murex rectirostris* Sowerby, 1841a, in the Indo-Pacific; and all of the New World species referred to *Murex* sensu stricto).

In addition to the nine vs. 12 proto-varices, all of the species of *Haustellum* are characterized by an overall lack of varical spines, except perhaps a shoulder spine, and especially by a lack of spines on the siphonal canal. It would appear that there are two only distantly related groups involved, one of which is *Murex* (*Murex*), with an extremely spinose shell, and one of which is *Haustellum*, with a shell that varies from sparsely spinose to no spines at all. In *Murex* (*Murex*) the color is usually monochromatic, overall cream to tan (a few species develop thin brown spiral lines), and invariably there is a more or less well-developed labral tooth. In *Haustellum* the shell usually has broad brown and white stripes, the aperture may be colored, and there is never a labral tooth, although there are frequently rugae on the often expanded labium (columellar lip).

In the Old World there is a species mixture of approximately 75% *Murex* sensu stricto to 25% *Haustellum*; but in the New World all species are to be referred to *Murex* (*Haustellum*). In the New World there are species that are so spinose as to seem referable to *Murex* (*Murex*) (e.g., *M. cabritii* Bernardi, 1859, in the Atlantic; *M. elencensis* Dall, 1909, and *M. ruthae* Vokes, 1988, in the eastern Pacific) but on all other criteria they are descendants of the *Haustellum* line

and must represent the ultimate in convergence. The reverse situation exists in the Old World with the species *M. brevispina* Lamarck, 1822, and *M. macgillivrayi* Dohrn, 1862, which lack spines on the canal and, at first glance, seem more akin to the subgenus *Haustellum*. However, they still have the strong labral tooth and the monochromatic color pattern and are assumed to be the non-spinose end of the *Murex* (*Murex*) spectrum. Jousseume (1880, p. 335) solved this problem by proposing another generic name, *Tubicauda*, and this may prove to be a solution for the American species as well. For the time being, the simplest course is to let geography and phylogeny overrule morphology and consider these few American species as the most spinose of the *Haustellum* group.

My concept of muricine evolution has also evolved through the years and with the addition of new species, new dates, etc., the basic pattern proposed in earlier publications (Vokes, 1963a, 1965, 1967c) must be slightly modified. Certainly *Phyllonotus* Swainson, 1833, is the oldest form of this group. A good Eocene species of *Phyllonotus* is now known, although not yet described. *Phyllonotus* presumably gave rise to *Siratus* Jousseume, 1880, and *Chicoreus* Montfort, 1810; by the lower Miocene all three are well represented. In the western Atlantic the *Siratus* group continued alongside the evolving *Haustellum* lineage but apparently never reached the eastern Pacific, although from all evidence it somehow reached the western Pacific (see further discussion under *M. pennae*, p. 29).

The *Haustellum* line in the New World seems to have begun with *Murex* (*Haustellum*) *messorius* Sowerby, 1841a, which so far as we can determine, was independently derived from the *Chicoreus* (*Siratus*) group. This conclusion is inevitable when one studies the muricids of the Dominican Republic. There are two distinct species present — *M. messorius* and *Chicoreus* (*Siratus*) *domingensis* (Sowerby, 1850) — that are so nearly alike in ornamentation it is difficult to separate them. Indeed, in the material collected by the U. S. Geological Survey in the 1919 expedition to the Dominican Republic (Vaughan *et al.*, 1921) all specimens of both of these species are reported as *M. domingensis* and I figured one of the misidentified specimens of *M. messorius* as *Murex domingensis* (Vokes, 1963a, pl. 1, fig. 6). With adequate collections the two are readily separable by the straight (*M. messorius*) vs. the bent (*C. domingensis*) siphonal canal, and once this is recognized the distinction is apparent. Shells that lack the canal are easily confounded. However, a more extended outer lip will still permit recognition of *M. messorius*.

In addition to this similarity of the two early forms, the color pattern of the living *Murex* (*Haustellum*) *messorius* with its wide brown stripes and generally dark

color is much more akin to that of the *Chicoreus* (*Siratus*) lineage than it is to the Indo-Pacific members of *Murex* (*Murex*). The other separating factor between *Murex sensu stricto* and *Haustellum* is the almost invariable presence of rugae on the columellar lip of the latter. Although not all of the species of *Haustellum* still retain these rugae, some having lost them secondarily, none of the *Murex* (*Murex*) have them and the presence of rugae is a sure indication of a *Haustellum* relationship. These rugae are invariably present in the *Siratus* group.

In the interval since the Miocene many of the descendent species have lost the labial rugae (e.g.: *M. anniae* Smith, 1940; *M. sallasi* Rehder and Abbott, 1951; and *M. bellegladeensis* Vokes, 1963a), although the majority do still have at least vestiges of them. In both the Atlantic and eastern Pacific lines there has been a move to increased spinosity — obviously it has survival value. In the Recent faunas, therefore, there are extremely spinose members on both sides of tropical America. This same trend is also seen in *Siratus*; there are species living today in the western Atlantic that are as spinose, except on the canal, as any Indo-Pacific *Murex* [for example, *Chicoreus* (*Siratus*) *articulatus* and *Chicoreus* (*Siratus*) *formosus*, both treated in the systematic portion below (see pp. 46 and 47)].

All of this discussion builds up to a philosophical dilemma. Should *Haustellum* be considered a subgenus of *Murex* or of *Chicoreus*? Would a more realistic solution be to give *Haustellum* generic status as is done in Ponder and Vokes (1988)? Given the various interweavings and convergences that seem apparent now, I prefer to retain the conventional assignments of *Murex* (*Haustellum*) and *Chicoreus* (*Siratus*) with the full realization that at the extremes of each group there are members that seem ill-placed.

Murex (*Haustellum*) *messorius* Sowerby Plate 1, figures 1–5

- Murex messorius* Sowerby, 1841a, pl. 194, fig. 93; Sowerby, 1841c, p. 137; Brown and Pilsbry, 1911, p. 353; Maury, 1917, p. 101(265), pl. 16(42), figs. 1, 2; Maury, 1920, p. 63; Vaughan and Woodring in Vaughan *et al.*, 1921, p. 167; Olsson, 1922, p. 131(303); Maury, 1925a, pp. 136–137, pl. 6, figs. 5, 10; Ramirez, 1956, p. 13 *et seq.*; Barrios M., 1960, p. 279, pl. 9, fig. 8; Vokes, 1965, p. 197; Fair, 1976, p. 58, pl. 3, figs. 33–35; Radwin and D'Attilio, 1976, p. 68, pl. 11, fig. 7; Vokes, 1979, p. 112.
- Murex nigrescens* Sowerby, 1841a, pl. 198, fig. 113; Sowerby, 1841c, p. 138.
- Murex funiculatus* Reeve, 1845, pl. 19, fig. 74; Reeve, 1846b, p. 88 (non *M. funiculatus* Schlotheim, 1820, nor DeFrance, 1827).
- Murex recurvirostris* Broderip. Gabb, 1873, p. 201; Pilsbry, 1922, p. 353; Woodring in Durham, Argellano, and Peck, 1955, p. 984 (not of Broderip, 1833).
- Murex subtilis* White, 1887, p. 137, pl. 11, fig. 11.
- Murex messorius* Maury not Sowerby. Vaughan and Woodring in Vaughan *et al.*, 1921, pp. 119, 128.

Murex sp. indet. Vaughan and Woodring in Vaughan *et al.*, 1921, pp. 128 [loc. USGS 8522], 160 [loc. USGS 8621].

Murex sp. a cf. *M. messorius* Sowerby. Woodring, Brown, and Burbank, 1924, p. 183.

Murex (Haustellum) messorius Sowerby. Trechmann, 1933, p. 38, pl. 4, fig. 14; Vokes, 1988, p. 16, pl. 1, fig. 4.

Murex (Murex) woodringi Clench and Pérez Farfante, 1945, p. 9, pl. 4, figs. 1-3; Vokes, 1965, p. 197; Vokes, 1967a, p. 81.

Murex (Murex) recurvirostris recurvirostris Broderip. Woodring, 1959, p. 214, pl. 35, figs. 5, 8, pl. 36, figs. 11, 12 (not of Broderip, 1833).

Murex (Murex) messorius Sowerby. Vokes, 1963a, p. 103 [not all references], pl. 3, figs. 6, 7 (not fig. 8 = *Murex (Haustellum) polynematicus* Brown and Pilsbry, 1911); Vokes, 1967a, p. 81, pl. 1, figs. 1 (lectotype), 2, 3, pl. 2, figs. 1-8.

Murex (Murex) domingensis Sowerby. Vokes, 1963a, pl. 2, fig. 6 only (not of Sowerby, 1850).

Murex (Murex) stultis White. Vokes, 1963a, p. 103, pl. 4, fig. 8.

Murex messorius var. *gustaviensis* Nowell-Usticke, 1969, p. 15, pl. 3, fig. 649.

Murex garciai Petuch, 1987, p. 66, pl. 11, figs. 9, 10.

Murex samui Petuch, 1987, p. 67, pl. 11, figs. 7, 8.

Mur. testa clavata, subventricosa, fulvo-rubescens, griseo, rubro, fuscoque maculata; spira brevi; cauda elongata, recta, angusta, minime recurva; varicibus tribus, crassis, costatis, ante crenulatis, pone foveolatis, ad angulum posticum spina brevi recta, ad caudam spina falcata, subelongata, deinde una brevior, recta; interstitiis duobus ad tribus costis noduliferis; apertura ovali, postice subcanalifera; labio interno postice tumido, intus crenulato; labio externo denticulato, antice paululum extante; canali fere clauso. Long. 2.40; lat. ex. var. .90 poll. [height 61 mm, width 23 mm] Hab. — ? Mus. Cuming. Stainforth.

Distinguishable by the thickened varices, and the spine at the base of the caudal canal, shaped like a reaper's hook. (Sowerby, 1841c, p. 137)

Description.—

The shell is moderately small (maximum length 65 mm) and club-shaped. The spire is high, consisting of one and one-half nuclear whorls and seven convex postnuclear whorls. The suture is moderately impressed. The body whorl is moderate in size and suborbicular. The aperture is moderately large and lenticular, with a small, shallow anal sulcus. The outer apertural lip is sinuous and crenulate, erect below the shoulder margin; its inner surface is denticulate. The columellar lip is adherent above, erect below, and bears a single knoblike node on the upper portion and several others near the margin on the lower portion. The siphonal canal is moderate in length, distally recurved, and narrowly open.

The body whorl bears three rounded varices, these sulcate on their trailing edges. Intervarical axial sculpture consists of three or four weak costae, nodulose where they intersect the major spiral cords. Spiral sculpture consists of ten major cords, intercalated with minor cords on the body and canal. Where each alternate major cord, beginning at the shoulder margin, intersects the varix, a short, closed, more or less posteriorly curved spine is evident. One such spine is developed at the top of the canal. (Radwin and D'Attilio, 1976, p. 68)

Diagnosis.—A trivariate muricid, each varix with one short spine at shoulder and one or two spines at posterior part of siphonal canal. Labium with several rugae. Siphonal canal very long, straight, former canals fused into a tube.

Lectotype.—BMNH 1964-349 (designated by Vokes, 1967a, p. 82).

Type locality.—Recent; St. Lucia, Windward Islands, Lesser Antilles (restricted by Vokes, 1967a).

Material.—This is the most widespread of the Dominican muricids, with over 400 specimens, occurring in every formation and at nearly every locality except those representing the deepest environments.

Measurements (in mm).—

specimen	height	diameter	locality
BMNH 1964-349*	64	29	(see above)
USNM 323851	49.2	30.8	TU 1294
USNM 323852	36.6	21.6	TU 1215
USNM 323853	32.3	13.7	TU 1230
NMB H 17002	41.4	22.0	NMB 17273
NMB H 16992	42.4	27.0	NMB 15833

* lectotype

Remarks.—As may be deduced from the synonymy above, *Murex (Haustellum) messorius* is the most common and widespread of all muricid species in the Neogene of the western Atlantic. Today it lives throughout the area south of Florida and north of the Amazon. The species is extremely variable and, consequently, has a number of synonyms. It is closely related to the tropical west American *Murex (Haustellum) recurvirostris* Broderip, 1833, and, as that name is older, has been so cited.

There is a considerable range of variation between specimens of *Murex (Haustellum) messorius* (as was documented by Vokes, 1967a) but usually at any given locality the morphology is relatively constant. Thus, at localities TU 1219, 1226, 1293, 1358, 1359 and 1364 (see Saunders, Jung, and Bijou-Duval, 1986, text-figs. 5, 21, 29, 23), for example, one sees the form with three or four intervarical nodes between each pair of varices; but at localities TU 1215, 1230, 1294 and 1354 (see Saunders, Jung, and Bijou-Duval, 1986, text-figs. 5, 15, 29) the more typical form with two or three intervarical nodes occurs. In the upper member of the Mao Formation (loc. NMB 15833 = loc. TU 1352; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 5), the NMB group collected a single specimen (Pl. 1, fig. 5) that is identical to Recent examples from the Virgin Islands. At López, on the Río Yaque (loc. NMB 17273 = loc. TU 1443; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 21), there is a most unusual morphotype (Pl. 1, fig. 4), which occurs with the typical form. It is possible that this is a new species but it seems, on the basis of the limited amount of material available, to be just an extreme variant.

Geologically, *Murex (Haustellum) messorius* is the oldest known species of *Haustellum* in the western Atlantic. It occurs in the Baitoa Formation, considered to be early Miocene on the basis of ostracode species

(see Bold, 1988, p. 11), and also in an unnamed formation on the south side of the Dominican Republic near San Cristobal (see *Remarks* under *Homalocantha* sp., p. 66, for a full discussion of this outcrop) in beds that have been dated by Akers (oral commun., 1977) as middle Miocene (Zone N. 11).

In the southern part of the Dominican Republic, near the Haitian border, in beds that are referred to the lower Las Cahobas Formation, the late Axel Olsson collected several specimens of *M. messorius*. The locality is on the Río El Marco, about 10 km northwest of Elías Piña. We were unable to reach the exact locality but material collected at Elías Piña was dated by Akers (oral commun., 1977) as N.13 (middle Miocene). Just across the Haitian border in beds of the Thomonde Formation, which on the basis of other molluscan fauna is assumed to be approximately the same age as the Baitoa Formation, a number of examples of *M. messorius* were collected by personnel of the U. S. Geological Survey (Woodring, Brown, and Burbank, 1924, p. 183).

In the undifferentiated beds of the Río Yaque del Sur at Boca Mula, west of Azua (loc. USGS 8621), a specimen of *M. messorius* was identified by Vaughan *et al.* (1921, p. 160) only as "*Murex* sp. indet.". Beds at nearby Quita Coraza have been dated by Akers (oral commun., 1977) as N.18, and so this occurrence is probably time equivalent to the Gurabo Formation.

Comparisons.—As noted above, the specimens that are likely to be confused with *M. messorius* in the Dominican beds are those of *Chicoreus* (*Siratus*) *domingensis* (Sowerby, 1850) that have the anterior canals broken off. With the canals present, the straight canal of *M. messorius*, in contrast to the deflected canal of *C. domingensis*, permits instant differentiation.

In the fauna of the western Atlantic, in general, there are a number of species closely related to *M. messorius*, but these have all lost the labial rugae and also have small secondary spinelets on the anterior portion of the varices. Only *Murex* (*Haustellum*) *recurvirostris* and its near kin in the eastern Pacific are likely to be confused with the Atlantic *M. messorius*. *Murex recurvirostris* sensu stricto of Broderip, 1833, may be distinguished by the extremely excavated back side of the varices and the darker color; *M. lividus* Carpenter, 1857, has also lost the labial rugae.

Occurrence.—Unnamed formations: San Cristobal area (south coast) (TU 1249); López area (TU 1443–1447; NMB 17275, 17278). Baitoa Formation: Baitoa area (TU 1226, 1363, 1364; NMB 16935, 16936, 16938, 16940, 16941, 17273, 17283, 17286, 17290). Cercado/Gurabo formations: Río Cana area (TU 1228, 1230, 1282, 1301, 1354, 1356, 1420; NMB 16817, 16818, 16821, 16828, 16835–16839, 16841, 16842, 16844, 16853, 16857, 16864); Río Gurabo area (TU

1210, 1211, 1212, 1214, 1215, 1231, 1247, 1277, 1278, 1296, 1298, 1358, 1359, 1373–1375, 1377, 1419; NMB 15811, 15814, 15816, 15843, 15846–15848, 15858, 15860, 15861, 15863, 15866, 15867, 15869–15871, 15873, 15878, 15896, 15898–15900, 15902–15907, 15910, 15911, 15916); Río Mao area (TU 1225, 1293, 1294, 1379, 1409, 1410; NMB 16910, 16912–16916, 16918, 16922–16924, 16926–16929, 16931, 16932, 17269); Río Amina area (TU 1219, 1220, 1411, 1412, 1455, 1456; NMB 16807); Santiago area (TU 1206, 1227A, 1250, 1403–1405, 1448, 1449, 1453, 1453A). Mao Formation: Río Gurabo area (TU 1352; NMB 15824, 15833); Santiago area (TU 1252).

Distribution.—Baitoa, Las Cahobas, Cercado, Gurabo, and Mao formations; Dominican Republic. Pirabas Limestone, Brazil; Thomonde Formation, Haiti; early Miocene. Unnamed formation, Veracruz, Mexico; middle Miocene. Quebradillas Limestone, Puerto Rico; late Miocene. Upper Tubará Group, Depts. of Bolívar and Atlántico, Colombia; Gatun Formation, Panama; Río Banano Formation, Costa Rica; Cumaná Formation, Venezuela; Pliocene. Bowden Formation, Jamaica; unnamed formation, Barbados; Pleistocene. Western Atlantic from Greater Antilles to Venezuela; Recent.

Murex (*Haustellum*) *pennae* Maury

Plate 1, figures 9–13

Murex domingensis Sowerby. Maury, 1917, p. 102(266) (in part, "the mutation with four or five intervarical ribs" only), pl. 16(42), fig. 5.

Murex pennae Maury, 1925a, pp. 140–141, pl. 6, fig. 4.

Murex (*Murex*) *pennae* Maury [emend.]. Vokes, 1963a, p. 102, pl. 4, fig. 5 (Maury, 1925a, pl. 6, fig. 4).

Murex (*Murex*) *domingensis* Sowerby. Vokes, 1963a, pl. 2, fig. 7 only (not of Sowerby, 1850).

Shell with somewhat the form of *Murex messorius* but with a much higher spire, and varices without spines. Whorls eight, including the nuclear. The spire is very high and the convex whorls are separated by a deeply impressed suture. The imprint of one side of the shell in the limestone [s]hows two varices extending continuously up the spire from whorl to whorl, almost vertically. The third varix is not shown. The varices are low, rounded, with [sic] no trace of any spines. On each whorl there are between the varices four [illustration shows five], narrow, low, longitudinal ribs. The spiral sculpture consists of very sharply defined spiral threads, nearly uniform though finer threads are sometimes interpolated. Anterior canal very long, perfectly straight, and the varices extend almost its entire length as sharp ridges. Aperture not preserved. (Maury, 1925a, p. 141)

Description.—Seven post-nuclear whorls in adult; protoconch of one-and-one-half bulbous turns. Spiral ornamentation of three or four cords per whorl, which persist to the penultimate whorl; with gradually a series of finer threads intercalated, one between each pair of major cords. On the body whorl, 11 or 12 strong cords, alternating with weaker ones; in addition, another five

strong cords on the siphonal canal. Axial ornamentation beginning abruptly at a small, sharp varix, with about 12 equi-sized axial ribs. By the second teleoconch whorl, every third rib strengthened to form a small varix with, at first, two intervarical ribs, gradually increasing to three, then four, finally five on the adult. Varices three per whorl, almost unornamented. A small spine may be produced where the spiral cord at shoulder crosses the varices; additional smaller spinelets occurring rarely on the anterior half of the varix and the extended canal. Varices extending up the spire in a straight line, not offset, resulting in the outer lip lying at an angle to the inner lip, rather than the two being in a horizontal plane. Spire greatly extended, suture impressed. Aperture elongate-oval; inner lip standing free except at the posterior end, where it is slightly appressed, denticulate almost its entire length, with a faint anal notch formed by a stronger denticulation at the posterior end of the columellar wall. Outer lip erect, standing much in advance of the terminal varix, bearing about 16 paired lirations that extend from the margin of the lip to well within the aperture. Siphonal canal long, straight, with previous canals fused together except at the extreme distal end, almost completely closed over by a plate of shelly material but open along a narrow slit, forming a tubular cover for the inhalant siphon.

Diagnosis.—A trivariolate muricid, each varix with only tiny spinelets. Labium with numerous rugae. Siphonal canal long, straight except at distal end.

Holotype.—Not found; plastotype, PRI 29313.

Type locality.—Pirabas Formation; mouth of Rio Pirabas, State of Pará, Brazil.

Material.—Over 200 specimens, almost all from the middle-depth facies of the Gurabo Formation; only four examples from the Cercado Formation.

Measurements (in mm).—

specimen	height	diameter	locality
Holotype ¹	50 ²	20 ²	(see above)
USNM 323854	48.0	23.1	TU 1219
USNM 323855	64.6	28.6	TU 1293
USNM 645428	36.4	16.5	TU 1293
USNM 323856	42.4	22.5	TU 1219
PRI 28749 ³	44.0	23.2	Bluff 1, Rio Mao ⁴

¹ not found; ² *vide* Maury (1925a); ³ specimen of Maury, 1917, pl. 42, fig. 5; ⁴ = TU 1293

Remarks.—The Maury 1916 Expedition collected examples of a species that she characterized (Maury, 1917, p. 266) as a "mutation" of *Murex domingensis*, "with four or five intervarical ribs, approaching *M. yaquensis*." They were said to come from "Bluff 1, Cercado de Mao" [loc. TU 1293; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 29] and "Zone F, Rio Gurabo" [loc. TU 1277, 1296; see Saunders, Jung, and

Bijou-Duval, 1986, text-fig. 5]. Had the party been able to collect the Gurabo fauna at the Potrero ford on the Río Amina (locs. TU 1219, USGS 8516; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 34), she probably would have realized that she had a new species. At this latter locality the form here referred to *M. pennae* is one of the most abundant muricine species (see Table 1), occurring with both *M. messorius* Sowerby, 1841a, and *C. domingensis* (Sowerby, 1850). The fact that all three are similar misled not only Maury but me, as I figured a specimen of *M. pennae* from the Río Amina as *Murex domingensis* (Vokes, 1963a, pl. 2, fig. 7).

With large collections it can be seen that the three species, although similar in ornamentation, each have distinctive differences that allow them to be separated immediately. *Murex* (*Haustellum*) *pennae* is unique among the Dominican murices in having the varices extend up the spire in a straight line, in contrast to the more normal sinuous line. As a result, the apertural lip stands at an angle to the inner lip, as is shown in Plate 1, figure 12. It never has the strong shoulder spines of *M. messorius*, with which it shares the straight siphonal canal, permitting both of the latter species to be distinguished from *C. domingensis*, with its bent canal.

These features are clearly shown in Maury's illustration of *M. pennae* (refigured here on Pl. 1, fig. 13), named subsequently from the Pirabas Limestone of Brazil. The type of Maury's species could not be located in 1971 in a search of the collections of the Museum in Rio de Janeiro, although others described by Maury at the same time were found. Fortunately, a "plastotype" has been deposited in the collections of the PRI. If the PRI plastotype is a faithful duplicate of the original mold (and there is some question), then the illustration given by Maury (1925a, pl. 6, fig. 4) is a rather imaginative reconstruction. But from the portions of the ornamentation that are present there is no reason not to call the Dominican Republic species the same as the Brazilian one.

The age of the Pirabas Limestone is as yet unresolved. It has yielded no planktic foraminifers nor calcareous nannofossils and the only age assignment must be made on the basis of the mollusks. In the Pirabas fauna *Orthis* *ornatus* Gabb, 1873, and *O. pugna* (Heilprin, 1886) occur together (Ferreira, 1967), as they apparently do in the early Miocene Tampa Limestone (see Vokes and Vokes, 1968, p. 74). Therefore, it is probable that the Brazilian formation is early Miocene in age, and may be correlative with the Baitoa Formation in the Dominican Republic.

The name *M. pennae* was given in honor of a man, Sr. Penna, and at the time I first considered this species (Vokes, 1963a, p. 102) an emendation was mandated [Art. 31(a)] by the *Code of Zoological Nomenclature*

Table 3.—Numbers of specimens of the three most abundant muricid species at selected outcrops along the Río Mao (See Saunders, Jung, and Bijou-Duval, 1986, text-fig. 29, for location of these localities.)

	"Bluff 3" (loc. TU 1294)	"Bluff 1" (loc. TU 1293)	above Mao Adentro (loc. TU 1292)
<i>Murex (Haustellum) messorius</i>	110	58	—
<i>Murex (Haustellum) pennae</i>	—	69	—
<i>Chicoreus (Siratus) domingensis</i>	—	7	36

(ICZN, 1961). Hence, the name was changed to *M. pennai*. In the Second Edition of the *Code* (ISZN, 1964), Article 31(a) was reduced to the status of a recommendation only. Thus, the older name could be restored. (The *-e* termination is the correct Latin formation for a masculine name ending in "a", the *Code* having ignored this point until the Third Edition (ICZN, 1985), which specifically states that a species-group name, if based upon a personal name that has been latinized, is to be formed in accordance with the rules of Latin grammar, giving as an example a species named for Nicolas Poda, if accepted as a Latin name, becoming *podae*.)

In the Gurabo Formation *Murex (Haustellum) pennae* is most abundant at the Potrero ford (loc. TU 1219), as noted above. It occurs only rarely along the Río Gurabo, *Murex (Haustellum) messorius* being the common species above the bridge and *Chicoreus (Siratus) domingensis* most common below the bridge in the deeper facies. Only in the lowermost beds of the Gurabo Formation, just above the contact with the Cercado Formation (locs. TU 1277, 1296 = Maury's Zone F; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 5), are there many specimens of *M. pennae* (14 from the two localities, in contrast to 18 from all of the rest of the river outcrops — Table 1 shows the relative number of each species at the various localities). In the Cercado Formation the species is so extremely rare that we and the NMB group combined collected just four specimens, three from the upper reaches of the Río Gurabo (locs. NMB 15899, TU 1375; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 5), and another on the Río Cana (loc. NMB 16835).

Along the Río Mao there is a similar situation, but it demonstrates even more clearly the "middle-depth" preference of *M. pennae*. From the more shallow Cercado Formation to the deeper Gurabo Formation localities along the Río Mao we see the numbers for the species given in Table 3.

Murex (Haustellum) pennae is one of several Dominican species that have their nearest relatives in the Indo-Pacific fauna. The Recent species *Murex (Haustellum) mindanaoensis* Sowerby, 1841a, is most similar, the only difference being that the Recent form has short spines along the varices and canal where *M. (H.) pennae* is almost totally smooth, with only a short spine at the shoulder and perhaps a few at the base of the

body whorl. In particular, the two species share the very long canal with recurved distal end, so that the ends of the canals ultimately diverge as in the subgenus *Siratus* Jousseaume, 1880. Whether the two disjunct species are truly closely related is a matter of conjecture, but when taken together with the other Indo-Pacific elements of the Neogene fauna of the Dominican Republic, such as *Chicoreus (Naquetia) compactus* (Gabb, 1873) and *Pterynotus neotripteris*, n. sp., the possibility becomes increasingly plausible. The fossil group of several Indo-Pacific species related to *Murex (Haustellum) bantamensis* Martin, 1895, would seem to be the link between the two (in particular, see the specimen figured by Ladd, 1977, pl. 14, fig. 1, as a paratype of *M. bantamensis coulsoni* Ladd, 1977, which is not *coulsoni*, but is very close to *M. mindanaoensis*).

The origin of the Indo-Pacific type species of the subgenus *Haustellum* Schumacher, 1817, is unknown, but on the basis of the color pattern and the aperture (which does have rugae well within the inner lip), it would seem to be descended from the New World side of the line. As is so often the case, the type species of *Haustellum*, *Murex haustellum* Linné, 1758, is the least "typical" member of the group. However, when one compares specimens of *M. haustellum* with, for example, the Indo-Pacific *Murex (Haustellum) hirasei* Hirase, 1915, or the Caribbean *Murex (Haustellum) chrysostoma* Sowerby, 1834, it is easy to see the derivation. Unfortunately the fossil record in the Indo-Pacific region is poor and we have no good idea of the sequence of evolution in the area. Considering how many of the species seem to be closely akin to *M. messorius*, the Pacific ancestor must have been much like the American form.

But somehow species of *Siratus* have made their way to the Old World also, as witnessed by the presence of *Chicoreus (Siratus) alabaster* (Reeve, 1845) [see below under *Chicoreus (Siratus) amplius*, n. sp., p. 49] and *Chicoreus (Siratus) pliciferoides* Kuroda, 1942. So perhaps the line of *M. mindanaoensis* also had its origins in the New World. We still have no idea of the mechanism of transportation, but there seems to be a growing body of evidence indicating that there has been movement of what we might consider "Indo-Pacific" and "Western Atlantic" lineages in both directions.

In the Pacific both *Murex (Haustellum) mindanaoensis* and *Chicoreus (Siratus) alabaster* live in deeper

water than is indicated for their Dominican counterparts — from the scant data available *M. mindanaensis* is found from 150–200 m (Radwin and D'Attilio, 1976, p. 68) to about 350 m (Vokes Coll.) and *C. alabaster* occurs at 250 m (Vokes Coll.). This depth is consistent with most of the Recent western Atlantic species of *Siratus*, however, so perhaps the group has been gradually moving into deeper water. Or maybe there were always deeper water species for which we simply have no fossil record.

Comparisons.—In the Dominican Republic beds the only species with which *Murex* (*Haustellum*) *pennae* could possibly be confused is *Murex* (*Haustellum*) *messorius*. From this latter, *M. pennae* is immediately distinguished by the deflected terminal ends of the siphonal canal and the varices neatly aligned up the spire. As noted above, the most similar species is the Indo-Pacific *Murex* (*Haustellum*) *mindanaensis*, which differs in having a more spinose shell, especially on the extended siphonal canal; the Dominican species being essentially non-spinose.

Occurrence.—Cercado/Gurabo formations: Río Cana (NMB 16835); Río Gurabo (TU 1211, 1213, 1214, 1215, 1246, 1277, 1296, 1375; NMB 15817, 15863, 15866–15869, 15899, 16808); Río Mao (TU 1280, 1293; NMB 16910); Río Amina area (TU 1219, 1371, 1411, 1412, 1455, 1456); Santiago area (TU 1206, 1250, 1403, 1405, 1449).

Distribution.—Cercado and Gurabo formations, Dominican Republic. Pirabas Limestone, Brazil; early Miocene.

Murex (?*Haustellum*) *adelosus*, new species

Plate 1, figures 6, 7

Etymology of name.—Gr. *a* = without, + *delosis* = explanation.

Description.—Shell consisting of five post-nuclear whorls and a protoconch of two smooth, bulbous turns. Spiral ornamentation beginning abruptly with three cords, gradually increasing in number to four sets of alternating major and minor cords on the penultimate whorl; eight to ten pairs on the body whorl, plus an additional six pairs on the extended siphonal canal. Axial ornamentation beginning very faintly; by second post-nuclear whorl approximately 15 small equal nodes; after two complete whorls, a strong varix developed. Subsequent varical formation irregular at first but by fourth post-nuclear whorl stabilized at three varices per whorl and three intervarical nodes between each pair. Varices rounded, deeply excavated abaperturally, ridged by spiral cords. On anterior portion, especially on the siphonal canal, a small flange along the outer margin. Spire very low, suture impressed but not channeled. Entire surface covered with intersecting spiral

cords and axial growth lines to give a malleated appearance to shell. Aperture oval, inner lip free-standing, with approximately 12 elongate denticles along the entire length. Outer lip serrate, margin scalloped by the spiral cords. Siphonal canal long, broad, straight except at distal end, almost completely covered by a plate of material extending from the columella, but open by a narrow slit.

Diagnosis.—Low-spined muricid with three heavy, deeply excavated, non-spinose varices on each whorl. Labium rugose. Long, broad, straight siphonal canal, with narrow flange on outer margin.

Holotype.—NMB H 17000.

Type locality.—Locality NMB 16818, Gurabo Formation; Cañada de Zamba, west side of Río Cana, approximately 4.5 km (airline) below the ford at Caimito, Dominican Republic (= loc. TU 1354; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 15).

Material.—The type lot of 12 specimens, all from the shallow-water facies of the Gurabo Formation or the Cercado Formation.

Measurements (in mm).—

specimen	height	diameter	locality
NMB H 17000 ¹	42.7	24.4	NMB 16818
NMB H 17001 ²	39.4 ³	23.0 ³	NMB 16818
PRI 33033 ⁴	42.6	25.5	TU 1354

¹ holotype; ² paratype; ³ incomplete; ⁴ unfigured paratype

Remarks.—In the shallow-water portions of the Gurabo Formation and in the Cercado Formation there are 12 specimens of an unusual species that is most akin to an equally strange species I figured as *Murex* (*Haustellum*) sp. (Vokes, 1974b, pl. 3, fig. 2), in a comparison with the Recent Australian species *Murex* (*Haustellum*) *wilsoni* (D'Attilio and Old, 1971). At the time of that discussion, only a single example of the American form was known and the question was raised as to how an otherwise Indo-Pacific-appearing species of *Haustellum* might have made its way to the Pliocene of Venezuela. Since 1974, a second juvenile example, assumed to be the same species, has been collected in the Pliocene Río Banano Formation of Costa Rica, and it shows that, although the protoconchs are similar in shape between *Murex* (*Haustellum*) *wilsoni* and the unnamed species of *Murex* (*Haustellum*), there is a marked difference in the size of the protoconch; that of the Australian species is extremely large, 2.5 mm in diameter, but the American form (here figured, Pl. 1, fig. 8) is of a more normal 1.0 mm in diameter. In fact, it is nearer typical *Haustellum* in dimensions.

Discovery of this second example lends an air of credibility to the presence of this alien form in the New World and the specimens from the Dominican Republic further add to the pedigree of the form. How-

ever, if the Dominican species is truly ancestral to the Pliocene *Murex* (*Haustellum*) sp., then there may be more convergence than first seemed indicated. The Dominican species differs from the Venezuelan–Costa Rican one in having a broader siphonal canal with a narrow flange along the margin. It has the appearance of a cross between *Haustellum* and *Naquetia*! The subgeneric affinities are obscure, to say the least.

The early whorls of *M. (Haustellum) adelosus* and of *M. (Haustellum)* sp. are exactly alike with no regular varices formed until the fourth post-nuclear whorl, where three varices and three intervarical nodes per whorl appear. This is typical of most species of *Haustellum*, the main difference being the very low spire angle in the two American species. In contrast, the South African species *Murex (Haustellum) fallax* Smith, 1901, has the very large protoconch of *M. wilsoni* but the early whorls, otherwise, are most like those of the American species, with only faint axial nodes. Clearly, this sort of development is consistent with the subgenus *Haustellum*. Both the protoconch of *M. haustellum* and *M. fallax* have been figured by the writer (Vokes, 1978, pl. 1, figs. 8 and 9, respectively).

There seems little doubt that the two American species are more closely related to each other than to anything else. The protoconchs and early whorls are almost identical, as are the apertures, with their denticulate inner lip. The differences are limited to the siphonal canal, mentioned above, and the suture, which is strongly channeled in *Murex (Haustellum)* sp., but not channeled in *Murex (Haustellum) adelosus*.

Although *M. adelosus* may be ancestral to *M. (Haustellum)* sp., there is no available ancestry for *M. adelosus*. It is distantly related to the New World subgenera *Phyllonotus* and *Siratus*, as indicated by the denticulate inner lip. But other than that, nothing can be said.

Murex (Haustellum) adelosus, n. sp., is confined to shallow beds, coming from locality TU 1215 (= loc. NMB 15860; see Saunders, Jung, and Biju-Duval, 1986, text-figs. 5, 10, pl. 2, figs. 3, 4) in the Gurabo Formation and locality NMB 16835 in the uppermost Cercado. The type locality at Cañada de Zamba (loc. TU 1354 = loc. NMB 16818; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 15) is just above the base of the Gurabo Formation.

Comparisons.—There is no other species in either the Dominican Republic or anywhere in the western Atlantic that has any similarity to this unusual form. The nearest possible relative is an undescribed species that occurs in the Pliocene of Venezuela and Costa Rica, from which *Murex (Haustellum) adelosus* differs in having a non-channeled suture and a broader siphonal canal with a narrow flange along the edge. The more southern species has the narrow, straight, non-

flanged canal of typical *Haustellum*.

In general, the affinities of this new species seem to lie with the Indo-Pacific species of *Haustellum*, more than with any other group, and in particular, the Australian species *Murex (Haustellum) tweedianus* Macpherson, 1962. This latter species has a protoconch only a bit larger [1.5 mm in diameter vs. 1.0 mm in *M. (H.) adelosus*] and the early whorls are identical, with no varices until the fourth post-nuclear whorl. The suture is not channeled, there is a small flange along the outer margin of the varices and siphonal canal and, especially, the two species share a characteristic malleated surface appearance (see Pl. 1, fig. 7). Another Australian species, *Murex (Haustellum) wilsoni* (D'Attilio and Old, 1971), also has this malleated surface but lacks the varical flange. The outer lip of *M. tweedianus* is also more like *M. adelosus* than either *M. wilsoni* or the aforementioned (see p. 30) *Murex (Haustellum)* sp. compared to *M. wilsoni*, with strong forward-directed serrations. Except for the broad siphonal canal, *M. adelosus* might be said to be the New World analog of *M. (Haustellum) tweedianus*, and *M. (Haustellum)* sp. the New World analog of *M. wilsoni*. As before, there is still no mechanism whereby the two distant occurrences may be explained.

Occurrence.—Cercado/Gurabo formations: Río Cana area (TU 1354, 1422; NMB 16816, 16818, 16835); Río Gurabo (TU 1215; NMB 15860).

Distribution.—Cercado and Gurabo formations, Dominican Republic.

Genus **CHICOREUS** Montfort, 1810

Chicoreus Montfort, 1810, p. 611.

Type species.—*Murex ramosus* Linné, 1758, by original designation (ICZN Opinion 911, 1970).

Subgenus **CHICOREUS sensu stricto**

Chicoreus (Chicoreus) cornurectus (Guppy)

Plate 2, figures 6–9

Murex (Chicoreus) megacerus Sowerby. Gabb, 1873, p. 202 (not of Sowerby, 1834).

Murex cornurectus Guppy, 1876, p. 521, pl. 28, fig. 4; Guppy, 1910, pp. 6, 9; Guppy, 1911, p. 8.

Murex (Phyllonotus) cornurectus Guppy. Maury, 1917, p. 103(267), pl. 16(42), figs. 9, 10; Hubbard, 1920, p. 150; Vaughan and Woodring in Vaughan *et al.*, 1921, pp. 119, 141; Ramirez, 1956, p. 11 *et seq.*

Murex (Phyllonotus) sp. indet. Vaughan and Woodring in Vaughan *et al.*, 1921, p. 160 [loc. USGS 8572].

Not *Murex (Phyllonotus) cornurectus* Guppy. Olsson, 1922, p. 131(303) [= unnamed species].

Murex (Chicoreus) brevifrons Lamarck. Pilsbry, 1922, p. 352; Woodring, 1959, p. 216, pl. 35, fig. 12 only (not of Lamarck, 1822).

Murex brevifrons Lamarck. Maury, 1925a, pp. 138–139, pl. 6, figs. 7, 9 (not of Lamarck, 1822).

Chicoreus (Chicoreus) cornurectus (Guppy). Vokes, 1965, p. 186 (in part, not *Chipola* specimens), pl. 2, fig. 2; text-fig. 1 (lectotype); Vokes, 1974a, p. 84.

Murex (Chicoreus) cf. brevivfrons Lamarck. Jung, 1965, p. 521; Jung, 1969, p. 491, pl. 49, fig. 7.

Not *Chicoreus (Chicoreus) cornurectus* (Guppy). Jung, 1971, p. 192, pl. 10, figs. 8, 9 [= unnamed species].

Description.—

Ovate-turreted, with three varices, which are nearly continuous, and stout revolving ridges accompanied by finer lines; two or occasionally three variciform tubercles between each varix; varices fringed by subtubular spines, of which the one corresponding to the keel on the angle of the whorls is much the longest. Aperture oval, the inner margin callous, the outer margin dentate, the dentations running in pairs. Canal moderately long and slightly curved. (Guppy, 1876, p. 521)

Diagnosis.—Large muricid with three frondose varices per whorl; one frond at shoulder very long. Labium smooth. Moderately long, broad, recurved siphonal canal.

Lectotype.—BMNH GG. 20254 (designated by Vokes, 1965, p. 186).

Type locality.—Locality NMB 17287², Baitoa Formation; east side of Río Yaque del Norte, at Boca de los Ríos, just below the confluence of the Río Bao and the Río Yaque, Dominican Republic (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 21).

Material.—Over 200 specimens, from almost every locality in the Cercado and the Gurabo formations; rare examples in the Baitoa Formation.

Measurements (in mm).—

specimen	height	diameter	locality
BMNH GG. 20254 ¹	89.2	45.0 ²	(see above)
NMB H 16995	7.0 ¹	5.0	NMB 15871
USNM 323861	42.3	19.0 ²	TU 1294
USNM 323862	45.0	26.5	TU 1211

¹ lectotype; ² excluding shoulder spines; ³ incomplete

Remarks.—There has been a continuous debate since the time of Maury as to whether *Chicoreus (Chicoreus) cornurectus* is distinct from *Chicoreus (Chicoreus) brevivfrons* (Lamarck, 1822), the common West Indian species of *Chicoreus*. The two forms are similar; nevertheless, they are separable. The easiest way to distinguish them is by the varical fronds. *Chicoreus brevivfrons* always has two large spines, with a small spinelet between. These double spines may be seen on the spire whorls as well as the body whorl. *Chicoreus cornurectus* always has a much larger single spine at the shoulder. On very large specimens, such as the lectotype (figured

by Vokes, 1965, text-fig. 1) the second spine, which corresponds to the second large spine in *C. brevivfrons*, may be slightly larger than the remaining small spines, but it is always much less conspicuous than the major one at the shoulder. Otherwise the differences are minimal. The number of intervarical nodes tends to be two in *C. cornurectus*, but not always, as witness the specimen here figured in Plate 2, figure 7. Conversely, the number of intervarical nodes tends to be one in *C. brevivfrons*. The protoconchs are also similar; however, that of *C. brevivfrons* is approximately twice the size of that of *C. cornurectus*. The older of the two species is *C. cornurectus*, which occurs in the Baitoa Formation and in the early Miocene Cantaure Formation of Venezuela. Jung (1965, p. 521) cited the latter as *Chicoreus cf. brevivfrons*, but examples in the collections of the UCMP are *C. cornurectus*. It was also reported from the Pirabas Limestone of Brazil as *Murex brevivfrons* by Maury (1925a, pp. 138–139, pl. 6, fig. 7), but her illustration (refigured here, Pl. 2, fig. 9) shows that the species is *C. cornurectus*. Thus, *C. cornurectus* is a more southern contemporary of *Chicoreus (Chicoreus) elusivus* Vokes, 1974a from the Chipola Formation, to which it is closely related.

Only slightly younger, the oldest certain occurrence of *Chicoreus brevivfrons* is in an unnamed formation of Veracruz, Mexico (loc. TU 635), which has been dated as middle Miocene (Zones N.13–14) by Akers (1972, p. 11). This specimen has been figured (Vokes, 1974a, pl. 1, fig. 5), and the spine pattern can be seen to be identical to that of the living form.

In the Gatun Formation of Panama, *C. cornurectus* also occurs. I have specimens from two localities, and Woodring (1959, pl. 35, fig. 12) illustrates another broken example. (His pl. 35, figs. 11, 13, shows a different species, neither *C. cornurectus* nor *brevivfrons*.) However, the species identified by Olsson (1922, p. 303) from the "Gatun" beds of Costa Rica — now the Río Banano Formation — is not *C. cornurectus* but an undescribed new species.

Guppy (1910) reported the occurrence of *C. cornurectus* in the Springvale Formation of Trinidad. But no specimen was illustrated until Jung (1969, pl. 49, fig. 7) figured an example from the Melajo Clay Member of the Springvale Formation. Although he states that all examples were so worn as to make positive identification impossible, the specimen shown seems to have the single larger shoulder spine of *C. cornurectus* and it is assumed that all of the reports from Trinidad do refer to *C. cornurectus*.

In the Grand Bay Formation of Carriacou, West Indies, dated by Robinson and Jung (1972, p. 124) as middle Miocene (Zones N.10–11), there is a specimen that Jung (1971, p. 192, pl. 10, figs. 8, 9) cited as *Chicoreus (Chicoreus) cornurectus*. But his illustration

In 1965 I designated "Río Yaque" as the type locality. Although the species is not common there, it does occur on the Río Yaque del Norte. In the NMB collections there is one large example that is very like the lectotype. Therefore the NMB locality is added as a refinement of the previous restriction.

does not look particularly like either *C. cornurectus* or *C. brevifrons*. His specimen has almost no varical fronds whatsoever and no indication that there ever were any (*i.e.*, there are no broken spine bases). The body whorl tapers gently into the siphonal canal in contrast to the sharp line of demarcation seen in both *C. cornurectus* and *C. brevifrons*. Neither does it resemble *C. elusivus* or, in fact, any other known species of *Chicoreus*. It is almost certainly new.

In the Dominican Republic *C. cornurectus* occurs in the Baitoa (rarely — one large example from loc. NMB 17287 and a fragment from loc. TU 1363; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 21), Cercado, and Gurabo formations. Most examples are small (*ca.* 40 mm) but are found at almost every locality, especially localities TU 1215 (Saunders, Jung, and Biju-Duval, 1986, text-fig. 5) and 1219 (Saunders, Jung, and Biju-Duval, 1986, text-fig. 34) in the Gurabo Formation, and locality TU 1379 (Saunders, Jung, and Biju-Duval, 1986, text-figs. 15, 32), in the Cercado Formation. The largest entire specimen is from locality TU 1211 (Saunders, Jung, and Biju-Duval, 1986, text-fig. 5) and is 100 mm in height; however, the example in the NMB collections from the Baitoa Formation, if complete, would measure almost 150 mm and is the largest ever seen anywhere.

In the undifferentiated "Yaque Group" of the southern Dominican Republic, *C. cornurectus* was collected by the U. S. G. S. party (Vaughan *et al.*, 1921, p. 160; listed as *Murex* (*Phyllonotus*) sp. indet.) from locality USGS 8572, at Los Güiros. This locality is near those at Quita Coraza, which have been dated as N.18 by Akers (oral commun., 1977). It is assumed that the beds at Los Güiros are the time equivalent of the Gurabo Formation.

Comparisons.—In the Dominican Republic there is no other species with which *Chicoreus* (*Chicoreus*) *cornurectus* could possibly be confused. The contemporary *Chicoreus* (*Chicoreus*) *brevifrons* differs in the possession of two large fronds on the posterior portion of each varix. The more direct descendant of *C. cornurectus* in the Recent fauna is *Chicoreus* (*Chicoreus*) *spectrum* (Reeve, 1846a), the distribution of which is limited to the Lesser Antilles and northern South America. The only discernible difference is a greater elongation of the siphonal canal in *C. spectrum*. The anal notch in *C. spectrum* is more tightly closed than it is in most specimens of *C. cornurectus* or *C. brevifrons*, but very large specimens of *C. cornurectus* show a similar tightening.

Occurrence.—Baitoa Formation: Baitoa area (TU 1363; NMB 17287). Unnamed formation: López area (TU 1444, 1445, 1447; NMB 17273). Cercado/Gurabo formations: Río Cana area (TU 1230, 1282, 1354, 1422; NMB 16817, 16818, 16828, 16835, 16836, 16839,

16842, 16844, 16867); Río Gurabo (TU 1210–1215, 1246, 1277, 1296, 1298, 1358, 1359, 1375–1377, 1419; NMB 15803, 15804, 15816, 15824, 15832, 15846, 15847, 15849, 15858, 15860, 15863, 15865–15867, 15869, 15871, 15898, 15900, 15903, 15904, 15906, 15908, 15910, 15913, 15920, 16808, 16810, 16883, 16934); Río Amina area (TU 1219, 1371, 1411, 1412, 1456); Río Mao area (TU 1225, 1292–1294, 1379, 1409; NMB 16913–16916, 16918, 16924, 16927, 16928); Santiago area (TU 1206, 1227A, 1250, 1353, 1403–1405, 1448, 1449, 1456; NMB 17271).

Distribution.—Baitoa, Cercado, and Gurabo formations, Dominican Republic. Cantaure Formation, Venezuela; Pirabas Limestone, Brazil; early Miocene. ?Quebradillas Limestone, Puerto Rico; late Miocene. Gatun Formation, Panama; Pliocene. Melajo Clay and Courbaril beds, Trinidad; Mio-Pliocene.

Chicoreus (*Chicoreus*) *dujardinoides* (Vokes)

Plate 2, figures 10, 11

undescribed *Murex*: Richards, 1943, p. 524.

Murex (*Chicoreus*) *lepidotus dujardinoides* Vokes, 1963b, p. 155, pl. 1, fig. 3.

Chicoreus (*Chicoreus*) *dujardinoides* (Vokes). Vokes, 1965, p. 185, pl. 1, fig. 6.

Chicoreus dujardinoides (Vokes). Vokes, 1979, p. 112, pl. 1, figs. 7, 8.

Description.—

Shell large in size, whorls moderately convex. Nucleus of two smooth, slightly bulbous whorls; termination of nuclear whorls marked by appearance of ornamentation, both axial and spiral. Seven post-nuclear whorls in the adult, suture appressed. Axial sculpture consists of ten equal nodes on the early whorls; on the fourth and successive post-nuclear whorls certain of these nodes are strengthened to form three varices, with two intervarical nodes between each pair. Spiral sculpture consists of primary threads, three in number on the earliest whorls, increasing to approximately seven on the body whorl, with three additional primaries on the pillar. Intercalated between the primary threads are one secondary, and usually two tertiary threadlets. Entire surface of shell sculptured by minute laminar increments which give a shagreened appearance to the intervarical areas. The free edges of the varices are sharply fluted by a succession of laminae with open spinelets produced where the primary threads cross the varices. One larger open spine developed at the shoulder, and two series of large spinelets on the siphonal canal. Aperture subcircular; labium smooth, standing free at the anterior end, appressed at the posterior, with a slight anal notch. Outer lip crenulated with about 12 paired denticles. Siphonal canal moderately long, broad, and sharply recurved at tip; former canals conspicuously divergent. (Vokes, 1963b, p. 155)

Diagnosis.—Muricid with three rounded varices per whorl, these lacinated only on adapertural faces; two strong ridges between each pair. Labium smooth. Siphonal canal moderately long, broad, recurved dorsally.

Holotype.—USNM 644372.

Type locality.—Locality TU 547, Chipola Formation; Chipola River, Calhoun County, Florida.

Material.—One specimen from the Gabb Collection.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 644372*	32.5	18.5	TU 547
USNM 263955	34.5	19.0	TU 820
ANSP 4003	46.5	30.0	unknown

* holotype

Remarks.—In an earlier paper (Vokes, 1979) I figured the specimen from the Gabb Collection shown here (Pl. 2, fig. 11) and suggested that it probably was from the early Miocene beds at Baitoa. This decision was based upon the worn and rolled condition, plus the fact that we had not found another like it in the Dominican Republic.

We still have not found a Dominican specimen of *C. (C.) dujardinoides*, but in 1980 we did discover what is almost certainly the locality for Gabb's shell, Arroyo Hondo (see Saunders, Jung, Bijou-Duval, 1986, pl. 9; text-figs. 21, 25), a tributary of the Río Yaque del Norte, at Boca de los Ríos, just below the confluence of the Río Bao and the Río Yaque. Occurring at this place are two other Burdigalian muricids; one is *Chicoreus (Phyllonotus) infrequens* (Vokes, 1963b), described from the Chipola Formation (see p. 39), and the second is *Chicoreus corrigendum*, n. sp., which also occurs in the Burdigalian Cantaure Formation of Venezuela.

Comparisons.—In the Dominican fauna, the only species with which *Chicoreus (Chicoreus) dujardinoides* might be confused is the presumed contemporary *Chicoreus (Chicoreus) corrigendum*, n. sp. Although similar, *C. dujardinoides* has two intervarical nodes in contrast to the one large node of *C. corrigendum* and the anal notch is much more open in *C. dujardinoides*. As the specific name implies, this species is most closely related to the French Miocene species, *C. dujardini* (Tournouër, 1875), which has a higher spire that is cancellate in contrast to the nodose spire whorls of *C. dujardinoides*. In addition, very large specimens of *C. dujardini* reduce the number of intervarical nodes to one.

Occurrence.—?Baitoa Formation; locality not known.

Distribution.—?Baitoa Formation, Dominican Republic. Upper part of Chipola Formation, Florida; early Miocene.

Chicoreus (Chicoreus) corrigendum, new species

Plate 3, figures 3–5

Murex (Phyllonotus) compactus Gabb. Vaughan and Woodring in Vaughan et al., 1921, p. 147 (not of Gabb, 1873).

Chicoreus (Chicoreus) compactus (Gabb). Vokes, 1965, p. 187 (in part, not of Gabb, 1873), pl. 2, fig. 3.

Etymology of name.—*L. corrigendum* = that which is to be corrected [in reference to the incorrect species determination applied to the paratype specimen figured by Vokes (1965)].

Description.—Protoconch unknown; teleoconch with eight whorls in the adult. Axial ornamentation on early whorls of 12 equi-sized, rounded nodes; on the fourth teleoconch whorl every third node strengthened to form a small varix. For about one additional whorl the remaining nodes forming paired intervarical nodes, the adapertural one then disappearing to leave a single strong node between each pair of varices thereafter. Varices elaborately foliated on the adapertural face, with a series of projecting spike-like processes reflecting the spiral cords. Varices excavated adaperturally, and the varical flange folded over to extend in an adapertural direction, especially on the anterior portion. Spiral ornamentation on early whorls of five equal cords, gradually intercalating smaller threads. On the body whorl, eight or nine strong rounded cords, covered with smaller threads, best seen on backs of varices; with an additional three or four similar cords on siphonal canal. Aperture small, rounded, columellar lip smooth, free-standing at anterior end; only slightly appressed at posterior end, with a single large tooth forming posterior channel. Outer lip serrate, bearing within nine denticles that trail off into weaker lirations within aperture. Siphonal canal short, broad, recurved at distal end; tips of former canals diverging as short spurs.

Diagnosis.—Muricid with three sharply-laciniated varices per whorl; one heavy node between each pair of varices. Labium smooth. Siphonal canal short, broad, recurved.

Holotype.—NMB H 17003.

Type locality.—Locality NMB 17284, Baitoa Formation; east side of Río Yaque del Norte, at Boca de los Ríos, just below the confluence of the Río Bao and the Río Yaque, Dominican Republic (see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 21).

Material.—Seven specimens, all from the Boca de los Ríos area.

Measurements (in mm).—

specimen	height	diameter	locality
NMB H 17003 ¹	41.0	23.4	NMB 17284
USNM 113775 ²	36.5	20.0	unknown
USNM 323867 ³	21.5	11.6	TU 1364
PRI 33034 ⁴	36.7	19.8	TU 1364

¹ holotype; ² paratype A; ³ paratype B; ⁴ unfigured paratype

Remarks.—In the USNM collection, there is a specimen that was identified as *Murex (Phyllonotus) compactus* (presumably by Woodring) and said to be from Potrero, on the Río Amina. In 1965, having no Dominican material, I borrowed and figured this specimen as *Chicoreus compactus* (Vokes, 1965, pl. 2, fig.

3). But the TU collections from the Dominican beds at locality TU 1364 (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 21), near Baitoa, contain several examples of what can only be the same species, which is not *Chicoreus* (*Naquetia*) *compactus* but a new species, here named *Chicoreus* (*Chicoreus*) *corrigenum*. This occurrence, plus the fact that in spite of extensive collecting at Potrero (loc. TU 1219; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 34) not so much as a fragment of either the new species or of *C. compactus* has ever been seen, prompted a re-examination of the USNM shell. It is obvious that the Potrero locality is in error.³ The specimen has the identical type of (?) *Cliona* borings, the identical matrix with fragments of *Sorites* in the aperture and, in every way, is identical to those from Baitoa. Because of the uncertainty of the locality data this specimen, although better preserved than any other in the collections, has not been selected as holotype. The holotype is one of two examples taken by the NMB team, at a locality near that of ours but not quite the same. Locality TU 1364 is in Arroyo Hondo, locality NMB 17284 along the Río Yaque just above the mouth of Arroyo Hondo; stratigraphically they are the same.

In addition to the seven specimens in the type lot from Baitoa, there is a small example from the Burdigalian Cantaure Formation of Venezuela (loc. TU 1269), collected by Mr. J. Gibson-Smith, formerly of Caracas, which is also referable to this species.

Comparison.—This new species is superficially similar to the nearly contemporary *Chicoreus* (*Chicoreus*) *folioides* (Gardner, 1947) in the Chipola Formation of Florida, but differs in having a narrower shape, with a smaller, more rounded aperture that has strong denticles on the inner side of the outer lip. Both species have lirations on the inside of the lip, but those of *C. folioides* do not terminate in discrete denticles. In addition, the spiral cords of *C. corrigenum* are much stronger than those of *C. folioides* and more excavated behind the varices. The anal tooth is also much stronger.

From the younger *Chicoreus* (*Naquetia*) *compactus*, with which it was originally confused, *Chicoreus* (*Chi-*

coreus) *corrigenum* may be readily distinguished by the short forwardly-folded varical spikes, in contrast to the broad expanded varical flange of *C. compactus* (compare Pl. 3, figs. 2, 4). Even in battered and worn examples of *C. compactus* the shell has a distinctly triangular appearance and lacks the sharp break between the body and siphonal portions of the varices. The overall shape of *C. corrigenum* is very near that of the Recent species *Chicoreus* (*Chicoreus*) *florifer* (Reeve, 1846a) and its kin, *C. floridanus* Vokes, 1965, and *C. dilectus* (Adams, 1855c). The latter species all share the same sort of strong spiral cords seen in the Baitoa Formation species, but differ in the peculiar, almost closed, anal notch of the younger forms.

Occurrence.—Baitoa Formation: Baitoa area (TU 1364; NMB 17284).

Distribution.—Baitoa Formation, Dominican Republic. Cantaure Formation, Venezuela; early Miocene.

Chicoreus (*Chicoreus*) *cosmani* Abbott and Finlay Plate 2, figure 4

Murex spectrum Reeve. Humfrey, 1975, p. 131, pl. 15, figs. 10, 10a (not of Reeve, 1846a).

Chicoreus cosmani Abbott and Finlay, 1979, p. 159, figs. 1–9.

Description.—

Shell moderate in size for the genus, attaining a length of 79 mm, trigonally fusiform in shape. Spire acute, with an angle of 35° to 40°, and about 45 percent of the entire length of the shell. Nuclear whorls 1½ glossy-smooth, convex, small but bulbous, whitish to tan, and with a well-indented suture, followed by 8 or 9 convex, well-sculptured, post-nuclear whorls. First few whorls with a cancellate sculpture between the varices. Suture finely impressed and slightly wavy. Aperture relatively small, about one-fourth the length of the entire shell, and with the peristome entire. Parietal wall glossy, slightly raised, and tinted with yellow, orange-brown or pinkish. Outer lip scalloped and bearing 10 to 12 minute, raised, white denticles. Siphonal canal moderately broad, nearly sealed, and slightly recurved dorsally and to the right at the distal end. Former siphonal canal half as large, tube-like, recurved to the left, and bearing on its surface a half-dozen axial, irregular, small cords. Last (and earlier) whorls with three varices, originating just behind the varix above it on the previous whorl. Each varix in the body whorl bears 8 short, bi- or trifurcate, scaly, partially (or rarely entirely) closed fronds. Three of these fronds are on the right side of the siphonal canal. In the early whorls the top frond is usually twice the size of those below. Intervarical sculpture consists of 4, rarely 3, even-sized axial, low cords which are crossed by numerous finer, spiral cords, thus forming a pattern of low, rounded beads, or tiny knobs, all about the same size. Color of shell varies from a uniform brownish orange to a pale yellow orange, rarely white. Interior of aperture white, with an orange-stained columella. Operculum chitinous, light-brown, oval, unguiculate, with fine, scaly concentric growth lines. (Abbott and Finlay, 1979, p. 159)

Diagnosis.—Muricid with three frondose varices per whorl, all fronds approximately same length. Labium smooth. Siphonal canal long, broad, recurved, ornamented with one long frond.

³ *Cardium* (*Trigoniocardia*) *aminense* Dall, 1900, was described also as coming from "Potrero, Rio Amina". However, all of our specimens come from the Baitoa Formation (57 examples from locs. TU 1363 and 1364, four from TU 1226; 91 from NMB locs. at Baitoa; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 21) and Dall's type specimen matches them exactly in color and matrix. No examples have been collected at Potrero [see discussion of *Trigoniocardia aminensis* (Dall, 1900) in H. E. Vokes, 1989, p. 119]. Presumably, other species listed in Vaughan *et al.* (1921, p. 147) as having been collected at Potrero by Bland and Rowell are from Baitoa as well, but not all of them are, for the specimen of *Poirieria* (*Paziella*) *dominicensis* is not from Potrero or Baitoa, but possibly from the Río Verde (see *Remarks* under that species, p. 56).

Holotype.—USNM 783323.

Type locality.—Recent; Ocho Ríos, Jamaica, 10 to 15 ft (3 to 4.5 m).

Material.—One specimen from locality TU 1215.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 783323*	79.0	40.0	(see above)
USNM 323863	28.5	11.7	TU 1215

* holotype

Remarks.—A single specimen referable to the Jamaican species *Chicoreus* (*Chicoreus*) *cosmani* was collected at locality TU 1215 (see Saunders, Jung, and Biju-Duval, 1986, text-figs. 5, 10; pl. 2, figs. 3, 4). Unfortunately, the part of the shell bearing the major apertural spine was exposed and has been removed by erosion.

There is a slight difference in the protoconchs of the Recent and fossil examples of this species; the tip of the protoconch in the fossil is less submerged (Pl. 2, fig. 4c) and the diameter is a bit less (1.2 mm vs. 1.3 mm). But in view of the fact that only two specimens were available for comparison (one fossil and one Recent) this does not seem significant.

The depth range of *C. cosmani* is from 4 to 18 m, which makes it especially remarkable that the form has not been described earlier. Perhaps other collectors have confused it with *Chicoreus* (*Chicoreus*) *spectrum*, as did Humfrey (1975, pl. 15, figs. 10, 10a). The two are readily distinguished by the single large shoulder spine with three smaller spines of *C. spectrum*, in contrast to the five equal length spines of *C. cosmani*. Proportionally the siphonal canal of *C. spectrum* is much longer than that of *C. cosmani*.

According to Humfrey (1975, p. 132), dead specimens were found at the base of a coral reef in Orange Bay, "which suggests that the live shells in that area normally live within the reef." This observation is corroborated by the occurrence of our single specimen at locality TU 1215, in the coralline facies of the Gurabo Formation.

Comparisons.—*Chicoreus* (*Chicoreus*) *cosmani* is unlike any other Caribbean species, fossil or living, in the nature of the spiral ornamentation, which consists of flattened ribbon-like spiral bands. As the original authors note, it is completely distinct from the other species of Atlantic *Chicoreus* that commonly have one or two large intervarical nodes. Although they suggest that the Indo-Pacific counterpart of the form is *Chicoreus* (*Chicoreus*) *akritos* Radwin and D'Attilio, 1976, from Australia, the resemblance is probably coincidental. In truth, this species is unlike any other known species of *Chicoreus*, fossil or Recent, Atlantic or Pacific.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1215).

Distribution.—Gurabo Formation, Dominican Republic. Recent; Jamaica to the Virgin Islands.

Chicoreus (*Chicoreus*)

species cf. *C. (C.) clausii* (Dunker)

Plate 6, figures 2, 3

Murex clausii Dunker, 1879, p. 215, pl. 8, fig. 6.

Murex senegalensis Gmelin. Knudsen, 1956, p. 17, pl. 2, fig. 26 (in part, not including synonymy; not of Gmelin, 1791).

Chicoreus clausii (Dunker). Vokes, 1973, p. 15, figs. 1, 2; Fair, 1976, p. 31, pl. 9, fig. 113.

Muricanthus varius (Sowerby). Radwin and D'Attilio, 1976, p. 79, pl. 12, fig. 5 only (in part, not of Sowerby, 1834).

Chicoreus (*Chicoreus*) *clausii* (Dunker). Vokes, 1978, p. 391, pl. 5, figs. 2, 3.

Testa solida, turbinato-fusiformis, transversim granoso-costata, inaequaliter lirata, triviridiosa, inter varices nodo crasso signata; anfractus septem convexi, subangulati, ultimus spira duplo circiter longior; varices crassi, tuberculati squamisque erectis aculeiformibus instructi, squamae nonnullae minores, inter majores posita, squama postica maxima, paululum resupinata; rostrum longitudinis medioris, curvum; canalis angustus; apertura ovata-rotunda; color cochlearis albus vel flavescens, costae tubericque saepius fusci; columella arcuata et fauces albae. — Long. 55–64, diam. 32–36 mill.; long. aperturae usque ad finem rostri 35–40. (Dunker, 1879, p. 215)

Description.—Shell with maximum height about 70 mm; eight teleoconch whorls plus a protoconch of four papillose volutions, ending at a small sharp varix; spiral ornamentation on first post-nuclear whorl of three or four well-defined cords; smaller cords gradually intercalated, until entire surface covered by alternating major and minor cords, separated by smaller tertiary threads; approximately eight pairs of major and minor cords on body whorl; axial ornamentation on first post-nuclear whorl of 12 small rounded ribs, diminishing to nine on second whorl, of which every other one is enlarged into a small varix by the third whorl, with the alternating ribs remaining as strong intervarical nodes, one between each pair of varices; three varices per whorl, bearing sharp, slightly recurved spines at each of the major spiral cords, proportional in size to the strength of the cord, largest at the shoulder and just posterior to the base of the body whorl, somewhat smaller between these two and just posterior to the base; tertiary spinelets, directed at right angles to the aperture, ad communem appearing between each of the spine pairs; exact pattern variable but usually (anteriorly from suture) small, large, small, medium, small, large, and two interchangeable small or medium at the base of the body whorl, plus an additional one or two medium-sized spines on the extended siphonal canal; aperture triangular oval, small open anal notch formed by a strong ridge at the posterior end of the columellar wall; margin of outer lip serrate, with strong projections between the spiral cords; columellar lip smooth, inside

of outer lip almost smooth, bearing only a few faint lirations; siphonal canal moderately long for the group, recurved at the distal end with previous terminations diverging as spurs from the latest canal; almost closed over by a thin plate of shelly material but open by a narrow slit along outer edge.

Diagnosis.—Moderately large muricid with three varices per whorl, each ornamented by two large and two small spines; one heavy node between each pair of varices. Labium smooth. Siphonal canal long, broad, recurved, ornamented with two spines.

Holotype.—Berlin Museum (*vide* Dance, 1966, p. 285).

Type locality.—Recent; "Littus Guineense"; Tema, Ghana, West Africa (here restricted).

Material.—Three specimens from locality TU 1352.

Measurements (in mm).—

specimen	height	diameter	locality
Berlin Museum*	64	36	(see above)
USNM 365142	21.9	13.5	TU 1352
USNM 365143	33.2	23.9	TU 1352

* holotype; unnumbered specimen illustrated by Dunker (1879, p. 213). Range of measurements given by Dunker as "Long. 55–64, diam. 32–36 mill." (*vide* Dance, 1966, p. 285).

Remarks.—One of the more surprising finds at locality TU 1352, the gravity-flow into deep-water Mao Formation at Gurabo Afuero on the lower Río Gurabo (see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 5), were three examples of what, on the basis of the poor material involved, may be tentatively identified as *Chicoreus* (*Chicoreus*) *clausii* (Dunker) [figured here, Pl. 6, fig. 1]. Today this species lives along the west coast of Africa and its appearance in the New World is unexpected, to say the least.

One would anticipate that the species should be *Chicoreus brevifrons* (Lamarck, 1822), as that is the common West Indian species of *Chicoreus* today. But the Mao Formation specimens show a marked single shoulder spine rather than the double spines characteristic of that form. If not *C. brevifrons* then the obvious answer should be *C. cornurectus* (Guppy, 1876), so widespread in the older beds of the Dominican Republic. But the apertures of the Mao shells are much more triangular, with a broadly-open anal notch in contrast to the narrow, constricted notch seen in *C. cornurectus*. Also, these specimens all have but a single large node between each pair of varices. Although large specimens of *C. cornurectus* may exhibit a single node, the normal condition, and that invariably present in juvenile shells, is two or more nodes. Unfortunately the material on hand is too poorly preserved to be certain of the identification.

Although not rare, *C. clausii* has escaped the attention of earlier malacologists, perhaps because of con-

fusion with the superficially similar *Hexaplex varius* (Sowerby, 1834). (I have discussed this problem further in Vokes, 1973, p. 15.) It was considered a "three-varixed form" of *Muricanthus varius* by Radwin and D'Attilio (1976, p. 79), who noted that the shell figured by Knudsen (1956, pl. 2, fig. 26) as *Murex senegalensis* is this form.

The presence of a living West African species ties in well with the appearance in the Dominican area of *Pterynotus* (*Purpurellus*) *mirificus*, n. sp., a close relative of *Pterynotus* (*Purpurellus*) *gambiensis* (Reeve, 1845), and *Thais coronata* (Lamarck, 1822) [see Remarks under *Thais* (*Thaisella*) *trinitatis* (Guppy, 1869), p. 85], both members of the West African fauna today.

Comparisons.—At first glance *Chicoreus* (*Chicoreus*) sp. cf. *C. (C.) clausii* has the most resemblance to the common West Indian species, *Chicoreus* (*Chicoreus*) *brevifrons*, but the latter is immediately recognized by the two long spines, one at the shoulder and a second immediately below it. These two are then followed by three smaller spines on the anterior half of the varix. In contrast, *C. clausii* has one long spine at the shoulder, one at the base of the body whorl, with one smaller spine between the two larger ones. In addition, the protoconchs of the two species are completely different.

The only other species in the Dominican beds that might be compared with this form is *Chicoreus* (*Chicoreus*) *cornurectus*, which does not occur in the Mao Formation but is found in beds of comparable age in Panama. However, there is only a subgeneric similarity between the two, *C. cornurectus* having but one large spine at the shoulder and a series of strong lirations on the inner side of the outer lip.

Occurrence.—Mao Formation: Río Gurabo (TU 1352).

Distribution.—Mao Formation, Dominican Republic.

***Chicoreus* (*Chicoreus*) *enigmaticus*, new species** Plate 6, figure 4

Etymology of name.—*L. aenigma* = something obscure, inexplicable.

Description.—Shell with maximum height probably 50 mm. Early whorls missing but six whorls remaining, suggesting seven postnuclear whorls in adult. Spiral ornamentation of numerous threads of varying sizes; on body whorl six major cords, separated by six to nine smaller threads. Axial ornamentation on earliest preserved whorls of nine rounded ridges, every third one becoming increasingly stronger with the remainder becoming intervarical nodes, two between each pair of varices; these nodes extremely large and projecting. Three varices per whorl, ornamented by short, sharp, spike-like spines where they cross the spiral cords. Ax-

ial growth lines crossing the spiral threads giving markedly shagreened surface to shell surface. Aperture rounded; inner lip appressed at posterior end, free-standing at anterior end; small open anal notch formed by low knob at posterior end of inner lip, which is otherwise smooth. Outer lip crenulated by seven strong lirations located between the varical spines, each ending in a forward-directed projection along the margin. Siphonal canal short, broad, recurved dorsally.

Diagnosis.—Massive muricid with three varices per whorl, each ornamented by spike-like spines. Between each pair of varices two extremely large nodes. Labium smooth. Siphonal canal short, broad, slightly recurved.

Holotype.—USNM 323897.

Type locality.—Locality TU 1422, Cercado Formation; Arroyo Bellaco, which is a tributary of Río Cana from the east; coral reef that is exposed for approximately 1 km below the ford at Las Caobas Adentro, 3 km southwest of Las Caobas, Dominican Republic.

Material.—Holotype.

Measurements.—USNM 323897 (holotype); height (incomplete) 34.3 mm, diameter 24.6 mm; locality TU 1422.

Remarks.—From the coral reef on Arroyo Bellaco (loc. TU 1422), we have collected a single example of a species of *Chicoreus* totally unlike any other known. Although the specimen is poorly preserved with both the spire and canal damaged, it is so different from all other species I feel no hesitation in naming it here.

Although its assignment to *Chicoreus* is obvious, there is no species to which it seems to be related. It has three varices bearing short, sharp-pointed spines, and between each pair of varices two very large, rounded intervarical ridges that sinuate the suture line. The short spines and the large intervarical nodes are reminiscent of the subgenus *Phyllonotus* Swainson, 1833, but the varices are aligned up the spire and the aperture is typical of *Chicoreus* (*Chicoreus*) rather than *Chicoreus* (*Phyllonotus*).

The only species in the Muricidae to which it bears any resemblance is *Hexaplex* (*Hexaplex*) *tenuis* (Sowerby, 1879)⁴, which lives today off the coast of West Africa. For the first three or four teleoconch whorls that species has nine rounded axial ridges per whorl and only on about the fifth whorl do these develop into (usually) seven spinose varices. The Dominican shell also has nine rounded axial ridges on the earlier whorls (the protoconch and earliest whorls are, unfortunately, unknown). But every third one has the tendency to form a small varix and by the fourth teleoconch whorl

it has settled into a typical *Chicoreus* pattern of three varices, with between each pair two intervarical ridges.

Inasmuch as the nature of the aperture and the shell ornamentation with the appressed, sinuated suture and the spinose varices (however, three not seven in number) are identical in the two forms, perhaps our Dominican specimen is a member of the genus *Hexaplex* Perry, 1810, in disguise. In the fauna of West Africa there is a comparable situation with *Hexaplex varius* (Sowerby, 1834), a peculiar species that spends its early stages looking like a typical three-variced species of *Chicoreus* but then on about the sixth whorl realizes its *Hexaplex* heritage and transmutes the intervarical ridges into varices, becoming a normal *Hexaplex* with from five to seven varices on the adult body whorl. This strange situation was discussed further by Vokes (1973), who noted that *Chicoreus clausii* (see p. 36) also seems to be a *Hexaplex* in origin but goes through life as a counterfeit *Chicoreus*. Perhaps our Dominican shell is another member of this group of generically intermediate species that cannot decide if they are *Chicoreus* or *Hexaplex*. Given the numerous other West African elements in the Dominican fauna, it is not totally unreasonable. As noted above, the shell does not look like any other species of *Chicoreus* known; maybe this is because it is, in fact, a *Hexaplex* with only three varices.

A specimen of *Hexaplex* (*Hexaplex*) *tenuis* is figured here (Pl. 6, fig. 5) for comparison with this strange species of *Chicoreus*. This example was collected by John Phillips, under boulders in 1–3 m of water, at Diarama Point, Almadies Bay, near Dakar, Senegal. This is consistent with the occurrence of the fossil shell in the very shallow-water facies of Arroyo Bellaco.

Comparisons.—I know of no species with which this strange specimen may be compared. There is no question that it is a muricid, nor even any question that it should be assigned to *Chicoreus*. But there the answers stop. At this time, its generic affiliations remain an enigma.

Occurrence.—Cercado Formation: Río Cana area (TU 1422).

Distribution.—Cercado Formation, Dominican Republic.

Subgenus PHYLLONOTUS Swainson, 1833

Phyllonotus Swainson, 1833, expl. to pl. 100.

Type species.—*Murex imperialis* Swainson var. a [= *Murex margaritensis* Abbott, 1958, new name for *M. imperialis* Swainson, 1831, non Fischer von Waldheim, 1807], by subsequent designation, Swainson, 1833, pl. 109.

⁴ The holotype of this little known species, which is in the collections of the Museum Nationale d'Histoire Naturelle, Paris, is the same species as that better known as *Murex lyratus* Adams, 1853 (non Gmelin, 1791).

Chicoreus (Phyllonotus) infrequens (Vokes)

Plate 2, figure 5

Murex (Phyllonotus) infrequens Vokes, 1963b, p. 156, pl. 1, fig. 4.
Chicoreus (Phyllonotus) infrequens (Vokes). Vokes, 1967c, p. 143,
 pl. 1, fig. 10.

Description.—

Shell of moderate size, spire elevated. Nucleus consists of four polished, conical whorls, terminating in a crescentic varix. Seven post-nuclear whorls in the adult, more or less convex. Early post-nuclear whorls ornamented by 14 equal axial nodes, which are crossed by three spiral threads. On the third to fourth whorls three of these axial nodes become stronger, forming varices, with the others remaining as intervarical nodes; two to three between each pair of varices. Spiral sculpture consists of four to five primary threads on the medial portion of the shell with one secondary and two tertiary threadlets between each pair of primary threads; approximately 12 primary threads on the body whorl and pillar. On the anterior portion of the varices and on the extended siphonal canal small open spinelets are produced where the primary threads cross. Aperture oval in shape, labium thin, slightly flaring, marked by numerous rugae which are a reflection of the underlying ornamentation; weak posterior anal notch. Outer lip crenulated by 12 to 14 paired denticles. Siphonal canal short, broad, recurved. (Vokes, 1963b, p. 156)

Diagnosis.—Muricid with three rounded varices per whorl, crossed by spiral cords; two or three small intervarical ridges between each pair. Labium flaring, with numerous rugae. Siphonal canal short, broad, recurved, ornamented by small open spinelets only.

Holotype.—USNM 644374.

Type locality.—Locality TU 458, Chipola Formation; Chipola River, Calhoun County, Florida.

Material.—Three specimens from locality TU 1364.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 644374*	36.0	19.0	TU 458
USNM 323860	29.6	15.6	TU 1364

* holotype

Remarks.—Vokes (1979) discussed the probability that the Baitoa and the Chipola formations are of the same Burdigalian age. At that time, among the muricids there was but one specimen, of an undetermined provenance, that could be said to be unique to the two formations. In the summer of 1980, a Baitoa Formation locality was located where three specimens of a second Chipola species, *Chicoreus (Phyllonotus) infrequens*, were found.

Chicoreus infrequens (as the name implies) is never common, even in the Chipola Formation. Only from locality TU 546 (Tenmile Creek, "one mile west of Bailey's Ferry") are there more than one or two specimens in the TU collections, but it occurs at 16 Chipola localities throughout the section.

Comparisons.—In both the Chipola and (presumably) the Baitoa formations this species occurs with the superficially similar *Chicoreus (Chicoreus) dujar-*

dinoides (Vokes, 1963b), to which it bears only a generic resemblance, in that both have three varices and a short recurved siphonal canal. However, the flaring, rugose labium of *Chicoreus (Phyllonotus)*, in contrast to the narrow, smooth inner lip of *Chicoreus sensu stricto*, immediately differentiates the two forms.

Occurrence.—Baitoa Formation: Baitoa area (TU 1364).

Distribution.—Baitoa Formation, Dominican Republic. Chipola Formation, Florida; early Miocene.

Chicoreus (Phyllonotus) pomatus, new species

Plate 2, figures 1, 2

Etymology of name.—*L. pomum* + *atus* = having the nature of *C. pomum*, the "Apple Murex", the common western Atlantic Recent species.

Description.—Shell with seven post-nuclear whorls and a protoconch of three-and-one-half conical whorls. Spiral ornamentation beginning abruptly at termination of protoconch with, on the first whorl, three equal threads, gradually increasing in number and strength up to the adult body whorl with six strong spiral cords, each separated by numerous secondary and tertiary threadlets; an additional two or three cords on the siphonal canal. Axial ornamentation on the first teleoconch whorl of 12 equal nodes; gradually every third node strengthened to form a rounded varix, three to a whorl, the intervening two nodes becoming intervarical ridges. With increasing size one or two auxiliary ridges added, the first ridge aperturally from the varix always the strongest, each successive ridge decreasing in size. Surface of shell shagreened by numerous axial growth lines crossing the spiral threads. Prominent nodes formed at intersection of stronger cords and axial ridges; at varices small spinelets may be produced, especially on the apertural face. Suture appressed, whorls inflated. Aperture oval, outer lip crenulated along the margin, inner side with about a dozen lirations, some paired. Columellar lip flaring, detached at the edge, and bearing a series of denticulations along the entire length. At the posterior end one strong ridge delimiting anal channel. Siphonal canal short, broad, recurved at distal end.

Diagnosis.—Massive muricid with three rounded varices per whorl, ornamented by small open spinelets. Three or four weak axial ridges between each pair of varices. Labium wide, flaring, rugose on anterior half. Siphonal canal short, broad, recurved.

Holotype.—USNM 323857.

Type locality.—Locality TU 1215, Gurabo Formation; Río Gurabo, bluffs on both sides, from the ford on the Los Quemados-Sabaneta road upstream to approximately 1 km above the ford, Dominican Republic (= locs. USGS 8539–8543; Maury's Zone D; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5).

Material.—The type lot, consisting of 25 specimens.
Measurements (in mm).—

specimen	height	diameter	locality
USNM 323857 ¹	52.8	32.3	TU 1215
USNM 323858 ²	7.0	3.7	TU 1227A
PRI 33035 ³	55.0	34.0	TU 1210

holotype; ² paratype; ³ unfigured paratype

Remarks.—As discussed previously (Vokes, 1967c, p. 154), the common western Atlantic species *Chicoreus* (*Phyllonotus*) *pomum* (Gmelin, 1791) is confined to beds Pliocene and younger in age. Thus the discovery of Dominican specimens, which seemed referable to *C. pomum* initially, was not too surprising and was thought to confirm the younger age here assigned to the beds. However, the subsequent discovery of a small specimen with a well-preserved protoconch showed the species in question to be not *C. pomum* but the ancestor of the eastern Pacific cognate species, *C. peratus* (Keen, 1960).

Comparisons.—The eastern Pacific species *Chicoreus* (*Phyllonotus*) *peratus* is morphologically much like *C. pomum*, but the two may be distinguished by the different protoconchs. These have both been figured by Radwin and D'Attilio (1976, text-figs. 53 and 54) and are reproduced here (Text-fig. 18). It can be seen that the Dominican species has the protoconch (see Pl. 2, fig. 2) of *C. peratus*; however, it has the teleoconch morphology of *C. pomum*, with heavier varices and shell than has *C. peratus*.

Houart (1987, fig. 4) has demonstrated that the Brazilian species *Chicoreus* (*Phyllonotus*) *oculatus* (Reeve, 1845) has a protoconch almost identical to that of *C. peratus*, thus proving that the species, which is often synonymized with *C. pomum*, is a valid taxon. From *C. oculatus*, the Dominican Republic species *C. pomatus*, n. sp., differs primarily in its smaller size. The largest specimen of *C. pomatus* is the holotype, just over 50 mm in height; adult specimens of *C. oculatus* measure in excess of 120 mm. In addition, the intervarical nodes in *C. oculatus* are usually two in number, large, and equal in size. The intervarical nodes in *C.*

pomatus are three or four in number, small, and unequal in size.

Another morphological feature shared by *C. pomatus*, *C. peratus*, and *C. oculatus* is a relatively narrow inductura; narrow, that is, in comparison to the extremely expanded inductura present in the other species of *Phyllonotus*. On the basis of the extremely expanded inductura seen in *C. pomum*, as well as in *Chicoreus* (*Phyllonotus*) *margaritensis* (Abbott, 1958), type species of the subgenus, and in the eastern Pacific *C. (P.) eversoni* (D'Attilio, Myers, and Shasky, 1987), it is assumed that these species are descendants of *Chicoreus* (*Phyllonotus*) *globosus* (Emmons, 1858), which occurs in the Pliocene of the southeastern United States, from Florida to North Carolina. But these species with the more narrow inductura, namely *C. oculatus* in the western Atlantic, and *C. peratus* in the eastern Pacific, are descendants of the Dominican *C. pomatus*.

Occurrence.—Cercado/Gurabo formations: Río Cana area (TU 1230, 1354, 1356, 1422; NMB 16828); Río Gurabo area (TU 1210, 1215; NMB 15842, 15844, 15846, 15848, 15863, 15865); Santiago area (TU 1227A). Unnamed formation: López area (NMB 17278).

Distribution.—Cercado and Gurabo formations, Dominican Republic.

Chicoreus (*Phyllonotus*) *pomum* (Gmelin)

Plate 2, figure 3; Text-figure 18

Murex pomum Gmelin, 1791, p. 3527; Brown and Pilsbry, 1913, p. 495.

Murex asperimus Lamarck, 1822, p. 164.

Murex mexicanus Petit de la Saussaye, 1852, p. 51, pl. 2, fig. 9.

Murex pomiformis Martini, Mörch, 1852, p. 96.

Murex (*Phyllonotus*) *pomum* Gmelin. Woodring, 1928, p. 290, pl.

17, fig. 9; Clench and Pérez Farfante, 1945, p. 26, pl. 14, figs. 1–4 (not including references to *M. imperialis* Swainson, 1831, *M. oculatus* Reeve, 1845, or *M. globosus* Emmons, 1858); Olsson and Harbison, 1953, p. 234 (in part), not pl. 34, fig. 1 [= *Chicoreus* (*Phyllonotus*) *globosus*]; Weisbord, 1962, p. 285, pl. 26, figs. 1, 2. Not *Murex pomum* Gmelin. Mansfield, 1930, p. 83, pl. 11, fig. 9 [= *Chicoreus* (*Phyllonotus*) *leonensis* Vokes, 1967c].

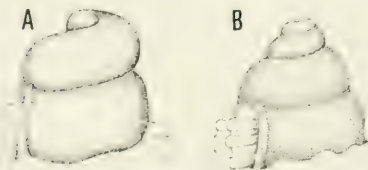
Chicoreus (*Phyllonotus*) *pomum* (Gmelin). Vokes, 1967c, p. 149, pl. 4, figs. 4, 5; pl. 5, figs. 4, 5.

Phyllonotus pomum (Gmelin). Fair, 1976, p. 68, pl. 10, fig. 126; Radwin and D'Attilio, 1976, p. 91, pl. 16, fig. 8, text-fig. 54.

M. testa ovata nodosa; varicibus tribus ad septem, cauda latiore. Habitat in mari, Africam occidentalem alluente, testa ponderosa, trunculo affinis. (Gmelin, 1791, p. 3527)

Description.—

The shell is moderately large (maximum length 120 mm) and globose-fusiform. The spire is moderately high to high, consisting of two smooth nuclear whorls and seven convex postnuclear whorls. The suture is generally obscured by the succeeding whorl. The body whorl is large and globose. The aperture is large and ovate, with a broad, shallow anal sulcus, this delimited parietally by a spiral ridge. The outer apertural lip is coarsely crenate and erect, most prominently anteriorly; its interior is strongly but briefly lirate. The col-



Text-figure 18.—Protoconchs of [A] *Chicoreus* (*Phyllonotus*) *pomum* and [B] *Chicoreus* (*Phyllonotus*) *peratus* (from Radwin and D'Attilio, 1976, text-figs. 53 and 54).

umellar lip is adherent and spreading, detached and erect below to form a moderate inductura; a long series of pustules of varying size and shape is found over the columellar region. The siphonal canal is broad, moderate in length, narrowly open to the right, and strongly, distally recurved.

The body whorl bears three or four nodose or briefly spinose varices. Other axial sculpture consists of one or two elongate nodes in each intervarical space. Spiral sculpture consists of alternating major and minor cords, these developed into knobs where they intersect the intervarical nodes, and into short, open, sharp spines where they intersect the varices. In addition, minute spiral threads and axial lamellae cover the entire shell. (Radwin and D'Attilio, 1976, p. 91)

Diagnosis.—Massive muricid with three heavy varices per whorl, ornamented only by open spinelets. One or two heavy axial ridges between each pair of varices. Labium wide, flaring, rugose on anterior half. Siphonal canal short, broad, recurved.

Type figure.—Martini, 1777, pl. 109, fig. 1023 (selected by Vokes, 1967c, p. 152).

Type locality.—Recent; St. Thomas, Virgin Islands (restricted by Clench and Pérez Farfante, 1945, p. 27).

Material.—Four specimens, from the Mao Formation.

Measurements.—USNM 323859; height 65.0 mm, diameter 44.8 mm; locality TU 1352.

Remarks.—As noted above, *Chicoreus* (*Phyllonotus*) *pomum* does not appear in the geologic record before the Pliocene (N.20). In the United States it is not present until the late Pliocene Caloosahatchee Formation. Not a single example has been found in the Florida Pinecrest beds or any of the correlative units farther north, such as the Yorktown Formation.

It would seem that the early Pliocene was a time of stress in the western Atlantic. In the entire area beds of this age are extremely limited, presumably an indication of lowered sea level. The resultant competition for *lebensraum* caused many changes in the molluscan fauna before and after. This can be seen in the Dominican beds where the Gurabo fauna metamorphoses into the Mao fauna; *Chicoreus* (*Siratus*) *domingensis* (Sowerby, 1850) is replaced by *C. articulatus* (Reeve, 1845) and *C. formosus* (Sowerby, 1841a); *C. pomatus*, n. sp. by *C. pomum*. The same change is seen in other genera, for example: *Strombus alatus* Gmelin, 1791, replaces *Strombus proximus* Sowerby, 1850; *Sconsia nephele* Bayer, 1971, replaces *Sconsia laevigata* (Sowerby, 1850).⁵

Presumably the change from the other ancestral species to their modern representatives also occurs at this time but the fauna of the Mao Formation is too poorly known to be certain. Unfortunately there is but

a single area where the Gurabo facies molluscan assemblage has been taken from the Mao Formation and this is in the lower reaches of the Río Gurabo, just above Gurabo Afuero. As noted in the *Introduction*, this is the portion of the upper member of the Mao Formation that contains gravity slumps. Here we see a typical "pebbly mudstone", containing gravel and shallow-water mollusks including species of Olividae, *Arca patricia* Sowerby, 1850, and *Chicoreus* (*Phyllonotus*) *pomum*, along with deeper-water mollusks such as *Chicoreus* (*Siratus*) *articulatus* and *Chicoreus* (*Siratus*) *formosus*. This locality is ecologically identical to the famous shell bed at Bowden, Jamaica (loc. TU 705), which also has *C. formosus*, *C. pomum*, and *Typhis* (*Talityphis*) *expansus* Sowerby, 1874a, all occurring together.

In the Recent western Atlantic fauna *C. pomum* is one of the more ubiquitous species, living from Cape Hatteras, North Carolina, to Venezuela, usually intertidally. Although it is not recorded in the literature, the species also occurs in the Gatun Formation of Panama (locs. TU 964, 965), the Agueguexquite Formation of Veracruz, Mexico (loc. TU 638), and the Moín Formation of Costa Rica (locs. TU 953, 954).

Comparisons.—Other than the aforementioned *Chicoreus* (*Phyllonotus*) *pomatus*, in the older beds of the Dominican Republic, there is no other species so far discovered with which *C. pomum* might be confounded. However, in the Recent fauna of the western Atlantic there are two closely related forms that have been placed in synonymy with *C. pomum* by some authors. The first of these is *Chicoreus* (*Phyllonotus*) *margaritensis* (Abbott, 1958), type species of *Phyllonotus*, which is immediately recognized by the presence of four or five varices per whorl. The second is *Chicoreus* (*Phyllonotus*) *oculatus* (Reeve, 1845), a larger, more elongate shell, which usually has two equal inter-varical ridges, in contrast to the usual pattern of one larger, one smaller ridge seen in *C. pomum*, and a multiwhorled protoconch in contrast to the paucispiral protoconch of *C. pomum* (see Houart, 1987, figs. 4, 6).

Occurrence.—Mao Formation: Río Gurabo (TU 1352, 1366).

Distribution.—Mao Formation, Dominican Republic. Agueguexquite Formation, Mexico; Gatun Formation, Panama; Mare Formation, Venezuela; Caloosahatchee Formation, Florida; Pliocene. Bermont Formation, Florida; Bowden Formation, Jamaica; Moín Formation, Costa Rica; Pleistocene. Western Atlantic from North Carolina to Venezuela; Recent.

Subgenus NAQUETIA Jousseaume, 1880

Naquetia Jousseaume, 1880, p. 335.

⁵ Although *Sconsia laevigata* has always been considered to be ancestral to the living species *S. striata* (Lamarck, 1816), the color pattern of *S. laevigata*, as seen under ultraviolet light, is identical to that of *S. nephele*, figured by Bayer, 1971, fig. 15.

Type species.—*Murex triquetus* Born, 1778, by original designation.

Remarks.—Within the broad grouping of *Chicoreus*, the divisions between the various subgenera are vague and frequently overlapping. In the Recent fauna of the western Atlantic the boundaries are not ambiguous and all species can be reasonably assigned to one or another subgenus but, as one goes back in time the distinctions become less clearcut. Vokes (1965, pp. 184 and 187, respectively) referred *Murex folioides* Gardner, 1947, and *Murex compactus* Gabb, 1873, to *Chicoreus* sensu stricto. Subsequently, work on *Chicoreus* (*Phyllonotus*) indicated that *C. folioides* would be better placed in that subgenus, but at the time there were no specimens of *C. compactus* available to me other than the one figured in the aforementioned work, which turns out not to be *C. compactus* at all, but a new species described herein as *C. corrigendum*. With additional material from the Dominican Republic it became apparent that *C. compactus*, although descended from *C. folioides*, does not seem especially like *Phyllonotus*; rather, with the expanded, lamellose varices, it seems more akin to the Indo-Pacific subgenus *Naquetia*. This is an awkward conclusion and almost certainly represents convergence on the part of the *C. folioides* lineage.

This interweaving and overlapping of supposed subgenera is found in both the New World and Old World species of *Chicoreus*. Although the subgenus *Phyllonotus* is confined (so far as I am concerned) to the New World, there is a group in the Old World denominated *Chicomurex* Arakawa, 1964 (type species: *Murex superbus* Sowerby, 1889), which is morphologically much like it. Formerly I considered the type of *Chicomurex* to be a member of the primarily western Atlantic subgenus *Siratus* Jousseaume, 1880. But of late several new species have been described that suggest the affinities of *Chicomurex* are more nearly with *Phyllonotus* and I now agree with Rehder and Wilson (1975, p. 7), who recognize this as a valid subgenus for a small group of Indo-Pacific *Phyllonotus*-like species whose ancestry goes back at least as far as the middle Miocene (Balcambian) species *Murex lophoessus* Tate, 1888, of southern Australia. Radwin and D'Attilio (1976) place most of the species that Rehder and Wilson placed in *Chicomurex* in *Phyllonotus*. I prefer to keep *Phyllonotus* distinct for the New World species and, on the basis of the arguments of Rehder and Wilson, recognize *Chicomurex* for the morphologically similar Indo-Pacific species.

All of the above simply indicates that the degree of convergence and parallel evolution in the broad group of *Chicoreus* is very marked. In effect, we see in both the Old World and the New twin lines leading to morphologically indistinguishable but only indirectly re-

lated forms. In the New World this would be: *Phyllonotus* to *Siratus* and (pseudo-) *Naquetia*; in the Old World *Phyllonotus* to *Chicomurex* and *Naquetia*.

Chicoreus (*Naquetia*) *compactus* (Gabb)

Plate 3, figures 1, 2

Murex (*Pteronotus*) *compactus* Gabb, 1873, p. 202.

Murex textilis Gabb. Guppy, 1876, p. 522 (in part, not of Gabb, 1873).

Murex (*Pteronotus*) *textilis* Gabb. Dall, 1890, p. 142 (in part, not of Gabb, 1873).

Murex compactus Gabb. Maury, 1917, p. 103(267), pl. 16(42), fig. 8 ("metatype").

Not *Murex* (*Phyllonotus*) *compactus* Gabb. Vaughan and Woodring in Vaughan et al., 1921, p. 147 [= *Chicoreus* (*Chicoreus*) *corrigendum*, n. sp.]; nor Woodring, Brown, and Burbank, 1924, p. 183 [= *Chicoreus* (*Phyllonotus*) *aldrichi* (Gardner, 1947)].

Murex rufus compactus Gabb. Pilsbry, 1922, p. 352, pl. 28, fig. 1 (lectotype).

Chicoreus (*Chicoreus*) *compactus* (Gabb). Vokes, 1965, p. 187, in part, not pl. 2, fig. 3 [= *C. (C.) corrigendum*, n. sp.].

Description.—

Shell short, thick, robust; spire about two-thirds as long as body whorl. Whorls eight; the first two nuclear, suture impressed. Body whorl broad above, tapering in advance, top sloping, very slightly concave. Varices three, short, robust, fimbriated or toothed on the margins, but bearing no spines or other elongate processes. Between each pair of varices, on the shoulder of the whorl, is a broad, blunt node. Surface ornamented by numerous large revolving ribs, blunt which are many smaller lines, all crossed by distinct, subsquamous lines of growth. Aperture small, sub-oval, inner lip with a faint tooth posteriorly; outer lip internally striate; canal short, blunt. (Gabb, 1873, p. 202)

Diagnosis.—Massive muricid with three varices per whorl, each ornamented with open spinelets on posterior half but with an expanded wing-like projection on anterior half. Labium smooth. Siphonal canal of medium length, only slightly recurved.

Lectotype.—ANSP 3258 (this specimen can no longer be located, *fide* Miller, written commun., 1979).

Type locality.—Locality TU 1230 (here restricted), Cercado Formation; Río Cana, east bank, just above the ford at Caimito on Los Quemados-Sabaneta road, Dominican Republic (= locs. USGS 8534; Maury's Zone H; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 15).

Material.—Over 40 specimens, from the shallow-water facies of the Gurabo Formation and the Cercado Formation.

Measurements (in mm).—

specimen	height	diameter	locality
ANSP 3258 ¹	56.4 ²	32.3 ²	TU 1230
USNM 323865	28.0	17.1	TU 1422
USNM 323866	32.5	19.0	TU 1230
PRI 28752	33.2	22.0	TU 1230 ¹

¹ holotype; ² *fide* Pilsbry, 1922, p. 352; ³ probably, on the basis of matrix in the specimen (of Maury, 1917, pl. 42, fig. 8 — "metatype sent by Professor Gabb from Santo Domingo")

Remarks.—The subgeneric placement of *Chicoreus compactus* is difficult. As may be seen from the synonymy it was confused with *Pterynotus* by Gabb and Guppy and this leads to the inescapable conclusion that *Naquetia* is the most acceptable pigeonhole for it. However, *Naquetia* is otherwise an Indo-Pacific subgenus and I feel somewhat uncomfortable mixing geography this way. However, the discovery of several other Indo-Pacific forms in the fauna, such as *Pterynotus neotripteris*, n. sp., *Dermomurex cracensis*, n. sp., *Spinidrupa radwini*, n. sp., and *Spinidrupa demissa*, n. sp., make the acceptance more palatable.

As noted above, *C. compactus* is almost certainly derived from the Chipola species, *C. folioides* (Gardner, 1947). In Florida the descendant of *C. folioides* is the middle Miocene Shoal River Formation species *Chicoreus (Phyllonotus) aldrichi* (Gardner, 1947) (see Vokes, 1967c, p. 144, pl. 3, fig. 2, for illustration and discussion). In the material collected by the U. S. Geological Survey at Las Cahobas in southern Haiti (loc. USGS 9908; see Woodring, Brown, and Burbank, 1924, p. 177) there is a single specimen (USNM 481841) that was identified as *Murex (Phyllonotus) compactus* Gabb, but examination revealed that this shell is, in fact, *C. aldrichi*. This discovery has two important implications: one, that the age of the beds of the Thomonde Formation may be somewhat younger than previously estimated (middle Miocene rather than late early Miocene); and two, *C. aldrichi* is the ancestor of *C. compactus*. This unexpected specimen, which is only the second complete example known, will be figured in a future publication.

If *C. compactus* is a member of the *C. folioides* line, presumably it is the last. There is no known species in the western Atlantic closely related to it. Originally I suggested (Vokes, 1965, p. 188) that *Chicoreus compactus* was an intermediate step between *C. dujardinioides* (Vokes, 1963b), from the lower Miocene Chipola Formation, and the Pliocene complex of *C. floridanus* Vokes, 1965, which today is represented by several species, including *C. florifer* (Reeve, 1846a). However, this was due to confusion with *C. corrigendum*, n. sp., in the Baitoa Formation, and the ancestry of the *C. floridanus*–*florifer* species complex seems more likely to have come from the Baitoa Formation species than the Chipola one. In either case, *C. compactus* has nothing to do with the complex.

Chicoreus (Naquetia) compactus occurs in both the Cercado and Gurabo formations but it is never a common species and one can only wonder where Gabb obtained the five examples said by Pilsbry to be in the type lot. In my experience no locality has yielded more than 10 specimens (loc. TU 1230) and most of these are immature. In all probability the type lot represents a composite sampling from several localities. Because

the species is most abundant at locality TU 1230, on the Río Cana, this locality is here restricted as the type locality.

Comparisons.—*Chicoreus (Naquetia) compactus* has been confused with *Chicoreus (Chicoreus) corrigendum*, n. sp., but the latter lacks the expanded wing-like projection on the anterior half of the varices. Lacking this fragile projection, as worn specimens of *C. compactus* commonly do, the principal difference immediately visible is the more deeply-indented suture of *C. corrigendum*, which causes the whorls of the latter to appear more inflated. The (presumed) ancestral species *C. aldrichi* also lacks the wing-like projection, has the impressed suture of the latter species, and has two intervarical ridges, in contrast to the single one of *C. compactus*.

Superficially, the most similar-appearing form is *C. folioides*, from the Chipola Formation, which has a strong single intervarical node and the triangular shape of *C. compactus*, but lacks the wing-like expansion.

Occurrence.—Cercado/Gurabo formations: Río Cana area (TU 1230, 1282, 1422; NMB 16841, 16848); Río Gurabo (TU 1215, 1231, 1246, 1377; NMB 15926). Unnamed formation: López area (TU 1447).

Distribution.—Cercado and Gurabo formations, Dominican Republic.

Subgenus *SIRATUS* Jousseaume, 1880

Siratus Jousseaume, 1880, p. 335.

Type species.—*Purpura sirat* Adanson, 1757 [= *Murex senegalensis* Gmelin, 1791], by original designation.

Chicoreus (Siratus) dominicensis (Sowerby)

Plate 4, figures 1–10; Text-figure 19

Murex dominicensis Sowerby, 1850, p. 49, pl. 10, fig. 5; Guppy, 1866a, p. 288; Guppy, 1876, p. 521; Gabb, 1873, p. 201; Dall, 1903, p. 1584; Maury, 1917, p. 101(265), pl. 16(42), figs. 3, 4 only [fig. 5 = *Murex (Haustellum) pennae* Maury, 1925a; fig. 6 = *Chicoreus (Siratus) amplius*, n. sp.]; Vaughan and Woodring in Vaughan et al., 1921, pp. 141, 149, 153; Pilsbry, 1922, p. 353; Rutsch, 1934, pp. 65, 136, pl. 4, fig. 2; Ramírez, 1950, p. 29, pl. 6, fig. 4; Ramírez, 1956, p. 13 et seq., pl. 3, fig. 16; Pflüg, 1961, p. 44, pl. 10, figs. 7–13 (figs. 8, 9, 13 = lectotype); Marciano F. and Tavares C., 1982, pp. 17, 27.

Murex (Murex) recurvirostris Broderip. Woodring, 1928, p. 288, pl. 17, figs. 7, 8 (not of Broderip, 1833).

Not *Murex dominicensis* Sowerby. Anderson, 1929, p. 137 [= unnamed species of *Chicoreus*].

Murex (Murex) dominicensis Sowerby. Vokes, 1963a, p. 106, pl. 2, figs. 8, 9 only [fig. 6 = *M. messorius* Sowerby, 1841a; fig. 7 = *M. pennae* Maury, 1925a].

Testa subovata, utrinque subacuminata, trifariam varicosa, anfractibus senis, longitudinaliter costellatis, spiraliter valde striatis; varicibus prominentibus, rotundatis, marginibus paucispinosus, spinis brevissimis; labio columellari antice ruguloso; canali breviuscula. (Sowerby, 1850, p. 49)

Description.—

Shell size average for the group. Spire elevated; inflation of whorls variable with resultant change in overall shape. Eight whorls in the adult; protoconch polished, bulbous, consisting of $1\frac{1}{2}$ whorls, axis eccentric. Three narrow varices developed on the earliest post-nuclear whorls, a single spine produced at the shoulder; occasionally small open spinelets on the anterior portion of the varices at the intersection with the primary spiral threads. Between the varices three to five narrow sharp axial ridges. Radial sculpture of primary and secondary threads with some tertiary threadlets; about 16 primary threads on the body whorl and pillar. Aperture variable from almost circular to oval; outer lip crenulated by about ten denticles; labium appressed at posterior portion, standing free at anterior portion, bearing eight to ten rugae. Anterior canal long and almost straight. (Vokes, 1963a, p. 106)

Diagnosis.—Trivariate muricid, each varix ornamented by short sharp spines. Labium rugose entire length. Siphonal canal long, narrow, weakly deflected dorsally.

Lectotype.—BMNH G. 83 948 (selected by Pflug, 1961, p. 45).

Type locality.—Locality TU 1293 (here restricted), Gurabo Formation; Río Mao, west bank, bluff just below Paso Chorrera, or about 12 km (by road) south of Mao (= locs. USGS 8519, 8520; Bluff 1 of Maury; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 29).

Material.—Over 1,000 specimens, all from the Gurabo Formation.



Text-figure 19.—Apertural and abapertural views of *Chicoreus* (*Siratus*) *domingensis* (Sowerby). Lectotype, BMNH G. 83 948, $\times 1\frac{1}{2}$. Height 44.6 mm, diameter 27.0 mm.

Measurements (in mm).—

specimen	height	diameter	locality
BMNH G. 83 948 ¹	44.6	27.0	TU 1293
USNM 323871	55.1	27.4	TU 1250
USNM 323872	41.6	21.0	TU 1211
USNM 323873	39.3	26.6	TU 1210
USNM 323874	32.4	17.8	TU 1210
USNM 643762	31.7	19.0	USGS 8528 ²
USNM 643763	8.0 ³	7.0	USGS 8528 ²
USNM 323876	34.9	18.2	TU 1214
USNM 323877	44.9	27.5	TU 1206
USNM 323875	35.0	21.5	TU 1210
NMB H 16989	54.3	30.7	NMB 16864

¹ lectotype; ² = loc. TU 1292; ³ incomplete

Remarks.—Three similar species of muricids occur together in the Gurabo Formation: *Murex* (*Haustellum*) *messorius* Sowerby, 1841a; *Murex* (*Haustellum*) *pennae* Maury, 1925a; and *Chicoreus* (*Siratus*) *domingensis*. Because they are superficially similar they have been confounded by authors, including me. In my *Cenozoic Muricidae, Part 1* (Vokes, 1963a), one of the specimens figured for *Murex domingensis* (pl. 2, fig. 7) is *M. pennae*; another (fig. 6) is *M. messorius*. These specimens were all taken from the collections made by the U. S. Geological Survey during their 1919 expedition to the Dominican Republic and identified by W. P. Woodring, who later (Woodring, 1928, p. 289) observed:

Maury records *messorius* from the Gurabo Formation, but apparently all the Gurabo specimens in the collections made by the United States Geological Survey party should be referred to *domingensis*, though it is virtually impossible to distinguish young shells.

Certainly *C. domingensis* is common in the Gurabo Formation and occurs at almost every locality, but it is usually accompanied by numerous examples of the other two forms. The number of specimens of each species present at the different localities is most enlightening (see Table 1). On the Río Amina all three forms occur in roughly equal proportions, but on the Río Gurabo below the bridge, there is an overwhelming preponderance of *C. domingensis*. Above the bridge, in the shallower beds, *C. domingensis* is essentially absent.

Other than in the Dominican Republic, *C. domingensis* is rare, but not unknown. Rutsch (1934, pl. 4, fig. 2) illustrated a large specimen of *Murex domingensis* from the Punta Gavilan Formation of Venezuela, and in the UCMP collections there is another large example from an unknown formation of (?) late Miocene age, on the Río Coatzacoalcas, near Jesus Carranza, Veracruz, Mexico (this specimen will be figured in a future paper). Anderson (1929, p. 137) listed *Murex domingensis* from the Tubará Group of northern Colombia but his specimen, in the CAS collections,

is a poorly preserved example of an undescribed species of *Chicoreus*.

The species that occurs in the basal Pleistocene Bowden Formation of Jamaica has been called *Murex domingensis* (Guppy, 1866a, p. 288; Dall, 1903, p. 1584). Woodring (1928, p. 288) stated that the Jamaican shell was not the same as *Murex recurvirostris* and he referred it to *Murex recurvirostris* Broderip, 1833 (which he considered an older name for *M. messorius*). I assigned the Bowden specimens to *Chicoreus* (*Siratus*) *antillarum* (Hinds, 1844) in the belief that this was the correct name for the species. As shown below, the Recent species so identified is now called *Chicoreus* (*Siratus*) *formosus* (Sowerby, 1841a). However, the specimens at Bowden are more akin to *C. domingensis* than to *C. formosus*.

In 1959 (p. 215), Woodring reiterated his belief that the Bowden species is *M. recurvirostris*, noting that *C. antillarum* "is larger, more spinose, and has a longer bent siphonal canal." The problem is due in part to the fact that there are numerous examples of what Woodring identified as *M. recurvirostris* [i.e., *Murex* (*Haustellum*) *messorius*] in the fauna at Bowden (loc. TU 705), but also the U. S. G. S. party never collected any specimens of typical *C. domingensis* in their Dominican Republic expedition.

The type lot of *Murex domingensis* in the BMNH is a very mixed bag. It contains 22 specimens, which include, in addition to the lectotype (figured here in Text-fig. 19), 21 paralectotypes. Of these only three are referable to *C. domingensis*, nine are *M. messorius*, eight are *M. pennae*, and one is *C. amplius*, n. sp. This mixture of species corresponds nicely to the fauna at Bluff 1 on the Río Mao (see Table 3) and, therefore, locality TU 1293 is here restricted as the type locality.

The majority of the specimens of *C. domingensis* found in the Dominican Republic are unlike the lectotype (selected by Pflug, 1961, pl. 10, figs. 8, 9, 13). Only in the more shallow-water portions of the Gurabo Formation are there examples that match this morphotype. The typical form occurs primarily along the lower reaches of the Río Cana (locs. NMB 16864–16868; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 15), but comparable examples have been taken at locality TU 1250 (in the shallow-water lens mentioned in the Introduction; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 38) and at locality TU 1206, which is the same locality that the material upon which Pflug based his study came from.

There is a remarkable degree of variability in *Chicoreus* (*Siratus*) *domingensis* [even though it is not as great as I previously admitted (Vokes, 1963a)], so much so that it is probable that two species are represented. The typical form is relatively slender, with three or four intervarical nodes, as in Plate 4, figures 1, 2, 8, and 9.

The more abundant morphotype is that shown in Plate 4, figures 3, 4, 5, and 10, an inflated shell with four or five intervarical nodes. At every locality the "fat" shells outnumber the "slender" ones (for example, loc. TU 1210 has 225 "fat" to 117 "slender", loc. TU 1219 has 76 "fat" to 58 "slender") and one is tempted to ascribe the differences to sexual dimorphism (not a muricid trait, unfortunately). However, at some localities, particularly the deeper-water ones, there are no examples of the slender form (loc. TU 1225 has 35 "fat", loc. TU 1227 has 15 "fat", TU 1292 has 36 "fat", but there are no "slender" examples at these localities) and so the only conclusion is that this is either an ecotypic variant or a different species.

Additional evidence toward the latter conclusion is a difference in protoconchs — the "fat" shells have a "fat" protoconch and the "slender" shells have a "slender" protoconch (compare Pl. 4, figs. 4 and 7). The "fat" protoconchs usually terminate with a strong varix, which is lacking in the slender ones. In spite of these differences, there is so much intergrading between the two forms that it is extremely difficult to make a definite line of separation between them and it may well be that *C. domingensis* is simply an unusually variable species. At least, it will be so treated for the present.

Although *C. domingensis* is by far the most abundant muricid in the Gurabo Formation, it is not known from either the Baitoa or the Cercado formations. The reason for this is probably ecological rather than stratigraphical. Both of these formations were deposited in much shallower water than was the Gurabo Formation. The range for *Chicoreus* (*Siratus*) *formosus* (Sowerby, 1841a) and *Chicoreus* (*Siratus*) *articulatus* (Reeve, 1845), the modern equivalents of *C. domingensis*, is from 50 to 350 m.

Comparisons.—Although *C. domingensis* is undoubtedly ancestral to the Recent species *C. formosus*, there are certain differences, which are constant. The Gurabo Formation species is smaller, less spinose, and has a more recurved siphonal canal than does *C. formosus*. Narrow flanges may be developed on the anterior portion of the varices but never spines as in *C. formosus*. Most of the specimens at Bowden are close to the typical *C. domingensis* but some (such as that figured by Vokes, 1963a, pl. 3, fig. 3) are indistinguishable from the Recent form. If one wished to be entirely accurate the Bowden shells probably should be cited as "*C. (S.) domingensis/formosus*".

From *C. articulatus*, the second Recent species thought to be descended from *C. domingensis*, the ancestral form differs in much the same ways as *C. formosus* does, having a less deflected siphonal canal. The reader is referred to *Chicoreus* (*Siratus*) *articulatus*, which follows, for further discussion.

It is with *Murex* (*Haustellum*) *messorius* that the

greatest amount of confusion has developed. *Murex messorius* and *C. (Siratus) domingensis* often occur together in the Dominican Republic and are, indeed, difficult to segregate when specimens are either immature or lacking the siphonal canal. However, even then, if one looks closely at the base of the canal it is usually possible to observe that the fusion of the previous canal takes place closer to the body whorl in *C. domingensis* and at an angle, which causes the canal to be broader (compare Pl. 1, fig. 1, and Pl. 4, fig. 1).

Occurrence.—Gurabo Formation: Río Cana (NMB 16864–16868); Río Gurabo (TU 1210–1215, 1277, 1278, 1296; NMB 15803, 15805, 15806, 15809–15814, 15816–15818, 15854, 15863, 15865, 16808–16810); Río Mao area (TU 1225, 1292, 1293; NMB 16801, 16910); Río Amina area (TU 1219, 1248, 1411, 1412, 1455); Santiago area (TU 1206, 1227, 1250, 1381, 1403, 1448, 1449, 1451–1453; NMB 17270).

Distribution.—Gurabo Formation, Dominican Republic. Unknown formation, Veracruz, Mexico; (?) late Miocene. Punta Gavilan Formation, Venezuela; Pliocene. Bowden Formation, Jamaica; Pleistocene.

Chicoreus (Siratus) articulatus (Reeve)

Plate 4, figures 11–13

Murex motacilla var. Sowerby, 1841a, pl. 189, fig. 69.

[?] *Murex antillarum* Hinds, 1844, p. 126 (*nomen dubium*; probably not *M. antillarum* of authors).

Murex articulatus Reeve, 1845 [June], expl. to pl. 22.

Murex nodatus Reeve, 1845 [August], pl. 25, fig. 107 (*non M. nodatus* Gmelin, 1791); Sowerby, 1879, p. 8, fig. 28.

Murex antillarum A. Adams [sic]. Sowerby, 1879, p. 8, fig. 209.

Murex gundlachi Dunker, 1883, p. 35, pl. 1, figs. 1, 2.

Murex sp. cf. *domingensis* Sowerby. Woodring, Brown, and Burbank, 1924, p. 242.

Murex antillarum Hinds. Clench and Pérez Farfante, 1945, p. 12, in part, not pl. 6 [= *Chicoreus (Siratus) formosus* (Sowerby, 1841a)].

Murex finlayi Clench, 1955, p. 1, figs. 1–3; Clench, 1959, p. 331, pl. 174, figs. 1–3.

Murex (Murex) recurvirostris recurvirostris Broderip. Perrilliat, 1972, p. 79, pl. 39, figs. 5, 6 only (not of Broderip, 1833).

Siratus articulatus (Reeve). Fair, 1976, p. 22, pl. 5, fig. 58; Radwin and D'Attilio, 1976, p. 104, pl. 17, figs. 2, 3.

Chicoreus (Siratus) articulatus Reeve. Vokes, 1980b, p. 91, figs. 3–5.

Shell abbreviately fusiform, clavate, attenuated at both ends, longitudinally subpubescent, transversely ridged, ridges nodiferous; three-varicose, varices rounded, armed with sharp small spines; yellowish-brown, encircled between the nodules with brown lines; canal rather long, obliquely ascending.

This shell was figured in the *Conchological Illustrations* by Mr. Sowerby, as a variety of the *Murex motacilla*, with which species he was probably not at the time acquainted, as it bears little or no affinity with it. (Reeve, 1845, expl. of pl. 25, *Murex nodatus*)

Description.—

The shell is moderately small (maximum length 55 mm) and fusiform. The spire is high and acute, consisting of one and one-half

nuclear whorls and six convex postnuclear whorls. The suture is moderately impressed. The body whorl is moderate in size. The aperture is moderately small, with a moderately broad and deep anal sulcus, this directed toward the parietal region. The outer apertural lip is erect and finely, marginally denticulate; its interior is barely lirate for a very short distance. The columellar lip is detached and somewhat erect, and bears two teeth at its posterior end, one at the lip margin, and one recessed into the aperture, these parietally delimiting the anal sulcus; at its anterior end the columellar lip bears three to five elongate, oblique pustules. The siphonal canal is long, more or less bent to the right, and narrowly open to the right.

The body whorl bears three spinose varices. Intervarical axial sculpture consists of three to five slender, elongate, nodulose ridges. Spiral sculpture consists of six major spiral cords, the uppermost one at the shoulder margin. Other spiral sculpture consists of intercalating minor cords and numerous threads. Where the major cords intersect the varices, short to moderately long, sharp, medially grooved spines are developed; the uppermost spine is the longest; the third and fifth spines below this are also strong and are essentially straight; the second, fourth, and sixth spines are shorter, sharper, and bent ventrally. A thin webbing of minor extent connects the last two spines and extends briefly below them. The canal bears a short and a longer spine. (Radwin and D'Attilio, 1976, p. 104)

Diagnosis.—Trivariate muricid, each varix with one long spine at shoulder and smaller spinelets or webbing on anterior portion, including the siphonal canal. Labium rugose entire length. Siphonal canal long, narrow, sharply deflected dorsally.

Holotype.—Not found. Type figure, Sowerby, 1841a, fig. 69 (here selected).

Type locality.—Recent; off Ocho Ríos, Jamaica (here restricted). Specimens most nearly resembling Sowerby's illustration are taken there in fish traps.

Material.—More than 100 specimens, all from the upper Mao Formation.

Measurements (in mm).—

specimen	height	diameter	locality
Holotype ¹	50 ²	25 ²	(see above)
NMB H 16993	35.0	21.6 ³	NMB 15833
NMB H 16994	26.9	14.3 ³	NMB 15833
USNM 792358	46.0	19.6 ³	Haiti ⁴
PRI 33036	34.6	23.2 ³	TU 1352

¹ not found; ² *vide* Sowerby (1841a); ³ excluding spines; ⁴ Île de la Gonave, 165 m

Remarks.—In the waters of the Caribbean Sea, off the Greater Antilles, there are two species of *Siratus* that are very similar in appearance and have been confused by many writers. One of these is *Murex formosus* Sowerby, 1841a, and the other is *Murex articulatus* Reeve, 1845. Both of these species have a particularly complicated nomenclatural history, which I have discussed in a previous paper (Vokes, 1965, p. 196). At that time it was assumed that *M. formosus* Sowerby was a senior synonym of the species that was cited as *Murex antillarum* Hinds, 1844, in a monograph on the western Atlantic muricids by Clench and Pérez Farfante (1945, p. 12).

Further work on *C. articulatus* for this paper (see also Vokes, 1980b) caused a deeper scrutiny into the identification of the various taxa associated with the species complex and it became apparent that the name *M. antillarum* Hinds is almost certainly to be applied to *C. articulatus*, and not to *C. formosus*. Hinds (1844, p. 126) described *M. antillarum* without illustration but stated, "I am strongly disposed to think that it is meant to be represented in fig. 69 of the 'Conchological Illustrations' [Sowerby, 1841a]." The species was not illustrated until 1879 in Sowerby's *Thesaurus Conchyliorum* (fig. 209) and there it is that species Sowerby had separated as his "*motacilla* var.", but the shell figured is not the type specimen of Hinds' species; rather it is a much larger individual.

The description given by Hinds leads me to think that his *M. antillarum* is the same as that shown in Sowerby's figure 69. He notes that his specimen is marked by dark transverse lines, which suggests the pattern of *C. articulatus* and not *C. formosus*. Unfortunately the type specimen of *M. antillarum* is lost. In 1984, an extensive search was made in the BMNH collections where Hinds' types are supposed to be, but no specimen matching Hinds' description could be found. Thus, we have no way of being certain which species was involved. In view of this fact and considering that *C. formosus* and *C. articulatus* are both well figured and have come to be associated with the two species involved, it seems in the best interest of nomenclatural stability to consider *Murex antillarum* Hinds as a *nomen dubium* and ignore it.

From a few exposures in the upper Mao Formation along the lower reaches of the Río Gurabo (locs. TU 1352, 1366, 1413; locs. NMB 15832, 15833; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 5) there are numerous examples of *C. articulatus* (more than 100) but the species is found nowhere else in the study area. Here are also the only examples of *C. formosus* (much rarer, only 15 in all), *Chicoreus* (*Phyllonotus*) *pomum* (Gmelin, 1791), and *Typhis expansus* Sowerby, 1874a. This area is unusual in that it represents gravity-flows of shallow-water material into the deep-water Mao Clay. Normally the fauna of the Mao Clay is limited to a few small molluscan specimens, mainly of *Limopsis ovalis* Gabb, 1873 or, at one locality (loc. TU 1300; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 5), terebratulid brachiopods (see Logan, 1987, pl. 12, figs. 1–11).

In the southern part of Haiti, in the Arrondissement of Jacmel, beds outcrop that were described by Woodring, Brown, and Burbank (1924, p. 240) as layers of conglomerate, interbedded with beds of marl carrying perfectly preserved fossils. Among these is an example of *C. articulatus* (USNM 482110, from loc. USGS 9530; Woodring, Brown, and Burbank, 1924, p. 242). In ad-

dition, in the NMB there is a large collection from the same area, which has a fauna identical to that seen on the lower Río Gurabo. The description of the outcrop indicates that there is an identical geological setting on the opposite side of the island.

Although the stratigraphic position of *Chicoreus* (*Siratus*) *articulatus* in the Mao Formation would seem to suggest that the form is a direct descendant of *C. domingensis*, in the Santa Rosa beds of southern Veracruz, Mexico, *C. (S.) articulatus* has been reported by Perrilliat (1972, p. 79, pl. 39, figs. 5, 6) as *Murex recurvirostris* Broderip. She attributes this fauna to the "middle Miocene Agueguexquite Formation", but the beds in the vicinity of Santa Rosa have been dated by Akers (oral commun., 1979) as N.17 or late Miocene (the true Agueguexquite Formation, which occurs only farther north near Coatzacoalcos, is N.20, Pliocene, in age), the same age as the Gurabo beds in which *C. domingensis* occurs. So, it is possible that *C. articulatus* may represent a different lineage. Furthermore, in the collections of the UCMP, in material from Bowden, Jamaica (= loc. TU 705), there is a specimen of *C. articulatus* among the more numerous specimens of "*C. (S.) domingensis/formosus*" (see p. 45).

Comparisons.—Although similar, *Chicoreus* (*Siratus*) *articulatus* may be distinguished from *Chicoreus* (*Siratus*) *formosus* by the greater angle of the siphonal canal in the former. The protoconchs of the two species also differ, that of *C. articulatus* being like the "fat" form of *C. domingensis* (see p. 45) and *C. formosus* more like the "slender" *C. domingensis*. (Compare Pl. 4, figs. 12b, 16, with Pl. 4, figs. 4b, 7b.) In addition, *C. articulatus* is usually smaller and is striped in some fashion with brown and white bands and reddish-brown spiral threads. In contrast, *C. formosus* is usually larger, and of an overall tan or brown color.

Occurrence.—Mao Formation: Río Gurabo (TU 1352, 1366, 1413; NMB 15832, 15833).

Distribution.—Mao Formation, Dominican Republic. Santa Rosa beds, Veracruz, Mexico; late Miocene. Unnamed formation, Haiti; Pliocene. Bowden Formation, Jamaica; Pleistocene. Caribbean Sea; Recent.

Chicoreus (*Siratus*) *formosus* (Sowerby)

Plate 4, figures 14–16

Murex rarispina Lamarck, 1822, p. 158, in part, not ref. to Martini, 1777, vol. 3, fig. 1056 [= *Murex trapa* Röding, 1798]; Kiener, 1843, p. 17, pl. 11, fig. 1; Reeve, 1845, pl. 21, fig. 86.

Murex formosus Sowerby, 1841a, pl. 197, fig. 112 ("Persian Gulf"); Sowerby, 1841c, p. 139 ("Loay, Ins. Bohol"); Sowerby, 1879, p. 6, fig. 380.

Murex (*Murex*) *antillarum* Hinds. Clench and Pérez Farfante, 1945, p. 12 (in part), pl. 6; Vokes, 1963a, p. 107 (in part), pl. 3, figs. 2, 3 (not of Hinds, 1844).

Murex antillarum Hinds. Smith, 1953, p. 3, pl. 1, fig. 16 (not of Hinds, 1844).

Chicoreus (Siratus) antillarum (Hinds). Vokes, 1965, p. 195, 196 (not of Hinds, 1844).

Siratus formosus (Sowerby). Fair, 1976, p. 43, pl. 5, fig. 56; Radwin and D'Attilio, 1976, p. 106, pl. 17, fig. 9.

Chicoreus (Siratus) formosus (Sowerby). Vokes, 1980b, p. 91, figs. 1, 2.

Mur. testa subclavata, transverse leviter costata, scabrosa, fulvo purpurascens; spira subproducta, aculeata; anfractibus novem rotundatis; suturis validis; cauda elongata, obliqua, tenui, recurva, validissime exfoliata; varicibus tribus a tergo subexcavatis, spina fere elongata ad angulum posticum, deinde tribus apertis subelongatis, cum parvis quinque ad sex proclivis alternantibus, ad caudam duabus mediocribus ferentibus; interstitiis trifariam noduloso-costatis; apertura ovali postice subcanalifera, labio interno antice vix minime exstante; labio externo denticulato, antice exstante; canali aperto. (Sowerby, 1841c, p. 139)

Description.—

The shell is moderate in size (maximum length 90 mm) and fusiform. The spire is high, consisting of one and one-half smooth, brown nuclear whorls and seven or eight weakly shouldered postnuclear whorls. The suture is moderately to weakly impressed. The body whorl is moderate in size and fusoid. The aperture is moderately large and ovate, with a broad, shallow anal sulcus. The outer apertural lip is somewhat erect and coarsely dentate at its margin. The columellar lip is adherent above, detached and erect below, and bears four moderately strong denticles at its anterior end and two strong denticles at the posterior end, one at the margin and one recessed and parietally delimiting the anal sulcus. The siphonal canal is long, weakly bent to the right and dorsally, and narrowly open to the right.

The body whorl bears three spinose varices. Intervarical axial sculpture consists of three nodulose ridges, these becoming progressively weaker in the direction of growth. Spiral sculpture consists of primary, secondary, and tertiary cords and of numerous intercalating threads. Where the primary and secondary cords intersect the varices, sharp, short to moderately long, straight spines are developed; of these, four are major, the uppermost one, at the shoulder margin, the longest. A thin varical webbing connects most or rarely all of the varical spines and is most prominent at the anterior end of the varix. The siphonal canal bears two or three spines, the uppermost minute, the middle one short but longest of the three, and the lowermost almost as long as the middle. (Radwin and D'Attilio, 1976, p. 106)

Diagnosis.—Trivariolate muricid, each varix ornamented with long sharp spines, that at shoulder longest. Labium rugose entire length. Siphonal canal long, narrow, weakly deflected dorsally.

Holotype.—Not found. Type figure, Sowerby, 1841a, fig. 112 (here selected).

Type locality.—Recent; Puerto Plata, Dominican Republic (here restricted).

Measurements (in mm).—

specimen	height	diameter	locality
Holotype ¹	79.8 ²	26.6 ²	(see above)
USNM 634487	49.0	22.0	off Jamaica, 73 m
NMB H 16990	54.6	33.7	NMB 15833
NMB H 16991	24.0 ³	15.0 ³	NMB 15833
PRI 33037	52.4	34.7 ⁴	TU 1352

not found; ² *vide* Sowerby, 1841b, p. 139; ³ incomplete; ⁴ excluding spines

Material.—Fifteen specimens, all from the upper Mao Formation.

Remarks.—Lamarck (1822, p. 158) described *Murex rarispina* as a trivariolate, spinose muricid, with the "partie nue de la queue assez grele", which he stated came from "Saint-Domingue". Having no available illustration of the species in question he referred to one in Martini (1777, fig. 1056), which is an Indo-Pacific form, making it a synonym of the older *Murex trapa* Röding, 1798, based on the same illustration. There is a slight resemblance between the two species in question, especially in the not very well-executed Martini figure.

Sowerby (1841a, pl. 197, fig. 112) presented a beautiful drawing of the species he denominated *Murex formosus*, giving it, however, an Indo-Pacific locality for some unknown reason. Shortly thereafter, Kiener (1843, pl. 11, fig. 1) illustrated Lamarck's species and the illustration he gives of *Murex rarispina* is clearly the Caribbean species *M. formosus*. Reeve (1845, pl. 21, fig. 86) then made the logical assumption that *M. formosus* and *M. rarispina* must be the same species, for which the Lamarck name clearly had priority.

Unfortunately the rules of nomenclature are not always logical and so, even though there is no doubt that the species Lamarck was describing is the Caribbean species, his choice of illustration fixed the name to the Indo-Pacific form. As the Martini figure may be regarded as that of a syntype of *M. rarispina*, in a work on the Indo-Pacific *Murex* sensu stricto (Ponder and Vokes, 1988), the specimen shown in this figure was designated as the lectotype of *M. rarispina* Lamarck, removing any chance of further nomenclatorial complications.

The doubt cast upon the identity of *M. formosus* by its association with the Indo-Pacific species *M. rarispina* (= *M. trapa*), as well as Sowerby's own mistake in locality, led authors to ignore the name *M. formosus* for a Caribbean species, and so when Clench and Pérez Farfante (1945) monographed the muricids of the western Atlantic, they selected *M. antillarum* Hinds 1844, as the oldest available name for the form. Of late, the name *M. formosus* has become recognized as the valid name for the species and, as discussed above (p. 47), *M. antillarum* is dismissed as a *nomen dubium*.

As with *Chicoreus (Siratus) articulatus* (Reeve, 1845), above, the only Dominican Republic fossil occurrence of this species is in the vicinity of Gurabo Afuero, on the lower Río Gurabo. This locality is older (N.20) than the Bowden shell bed, which has been dated by Lamb and Beard (1972, p. 32) as N.22. Thus it can be seen that, although *C. domingensis* (Sowerby, 1850) may have given rise to both *C. articulatus* and *C. formosus*, all three species co-existed for a time. In addition, there is a single incomplete specimen of *C.*

formosus from the uppermost beds of the Gatun Formation at Telfers Island, near Colón, Panama (see Vokes, 1983, p. 123 for a discussion of this unusual locality).

In the Recent fauna *C. formosus* is most commonly encountered in the Greater Antilles, although Clench and Pérez Farfante (1945, p. 14) report the species (as *M. antillarum*) from off Barbados and Grenada. In particular the island of Hispaniola seems to be a favorite haunt; harbor dredging at Puerto Plata, on the north coast, has strewn the beaches with subfossil examples. As "Saint Domingue" was also the locality for the example of "*M. rarispina*" figured by Kiener (1843), Puerto Plata is here restricted as the type locality for *C. formosus*.

Comparisons.—As noted above, *C. formosus* differs from the contemporary species *C. articulatus* in being larger, more spinose, with coarser ornamentation and a less-strongly deflected siphonal canal. From the ancestral *C. domingensis*, it may be distinguished by many of the same characteristics (e.g., larger size, coarser ornamentation, and more spinose shell. However, the angle of the siphonal canal is essentially the same in the two forms). Thus, in order to separate the three species one must look at the total assemblage of characters. The older *C. domingensis* is more like *C. articulatus* in size and ornamentation, but more like *C. formosus* in the nature of the siphonal canal.

Occurrence.—Mao Formation: Río Gurabo (TU 1352, 1366; NMB 15833).

Distribution.—Mao Formation, Dominican Republic. Gatun Formation, Panama; Pliocene. Caribbean Sea; Recent.

Chicoreus (Siratus) amplius, new species Plate 3, figure 6

Murex domingensis Sowerby. Maury, 1917, p. 102(266), pl. 16(42) fig. 6 only (not of Sowerby, 1850).

Etymology of name.—*L. amplius* = wider (in reference to the very large size, relative to other members of the subgenus in the Dominican fauna).

Description.—Shell with seven post-nuclear whorls in adult; protoconch unknown. Subdued spiral ornamentation of about 16 major cords on the body whorl, with intercalated smaller cords; an additional eight smaller cords on the siphonal canal. Axial ornamentation of three strong varices on each whorl; two or three small nodes between each pair of varices. On the varices a single short, sharp, spine at the shoulder, with a plate-like flange along the anterior portion of the varix. Aperture ovate, with a large anal notch; approximately 12 elongate denticles on the inner side of the outer lip; a thin projecting flange parallel to the axis of the shell in advance of the varix. Columellar wall appressed at the posterior end, bearing one large

denticle plus several lesser ones; free-standing at the anterior end, with three or more strong denticles. Siphonal canal short, broad, recurved at the distal end, bearing a single large spine about halfway along its length.

Diagnosis.—A large muricid with three winged varices on each whorl, each with a massive spine at the shoulder. Labium rugose for its entire length. Siphonal canal short, broad, recurved dorsally.

Holotype.—USNM 323868.

Type locality.—Locality TU 1293, Gurabo Formation; Río Mao, west bank, bluff just below Paso Chorera, or about 12 km (by road) south of Mao (Valverde), Dominican Republic (= locs. USGS 8519, 8520; Bluff 1 of Maury; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 29).

Material.—Five specimens, all from the shallow-water facies of the Gurabo Formation.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323868 ¹	71.0	50.0	TU 1293
PRI 28750 ²	75.2	44.2	Bluff 1, Río Mao ³

¹ holotype; ² unfigured paratype; specimen figured by Maury, 1917, pl. 42, fig. 6; ³ = loc. TU 1293

Remarks.—In the Gurabo Formation, in the vicinity of Cercado de Mao, there is a large new species of *Chicoreus* (*Siratus*) that has been confused with *Chicoreus* (*Siratus*) *domingensis*. Indeed, one of the syntypes of that species in the BMNH is referable to this new species, and a specimen was also identified by Maury (1917, p. 266) as "an extraordinarily large specimen (fig. 6), 74 × 42 mm, apparently referable to *M. domingensis*." However, the resemblance between the two is no more than subgeneric, and *Chicoreus* (*Siratus*) *amplius*, n. sp., more closely matches *C. (S.) tenuivaricosus* (Dautzenberg, 1927) from southern Brazil. It attains a larger size than any specimens seen of *C. domingensis*, but the real difference is in the more subdued ornamentation. Even very large specimens of *C. domingensis* show a more pronounced spiral ornament, which as it crosses the axial nodes gives rise to a more beaded appearance (compare Pl. 4, fig. 1, and Pl. 3, fig. 6). Another feature unique to this species⁶, so far as I am aware, is the projecting flange on the apertural lip. This is broken in the apertures of all specimens at hand, but may be seen on the previous varices where it has been melded into the new portion of the whorl (see Pl. 3, fig. 6b).

Chicoreus (*Siratus*) *amplius*, n. sp. is rare; there are only five entire specimens in the type lot, including the

⁶ In *Chicoreus* (*Siratus*) at least; a similar structure occurs in many species of *Murex* (*Haustellum*), strengthening the notion that *Murex* (*Haustellum*) might be ultimately derived from a *Chicoreus* (*Siratus*) ancestor. (See *Remarks* under *Murex* (*Haustellum*) [p. 25].)

one figured by Maury. The depth preference for the closely related species *C. (S.) tenuivaricosus* is from 15 to 30 m, which corroborates the shallow depth attributed to the beds at localities TU 1293 and 1225 (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 29).

Comparisons.—Although similar to *C. domingensis* with which it occurs, *C. amplius*, n. sp., may be recognized by its more subdued surface ornamentation, its winged rather than spinose varices, and by its very large size. This new species is closely akin to the living Brazilian species *Chicoreus (Siratus) tenuivaricosus* but differs in having a coarser surface ornamentation and in having several strong denticles on the inner lip. The Recent species has only a few faint denticles at the anterior end of the columellar lip.

This is another of the Dominican Republic species that has a very near relative in the Indo-Pacific fauna, in this instance *Chicoreus (Siratus) alabaster* (Reeve, 1845), which is extremely like the Brazilian *C. tenuivaricosus*, differing primarily in the large size of the Pacific form. Although *C. alabaster* has lost all trace of the columellar denticles, the outer lip has an expanded flange that is most akin to *C. amplius*, suggesting that the Dominican species might be ancestral to both lines.

Occurrence.—Gurabo Formation: Río Mao area (TU 1225, 1292, 1293); Santiago area (NMB 17270).

Distribution.—Gurabo Formation, Dominican Republic.

Chicoreus (Siratus) yaquensis (Maury)

Plate 3, figures 7–10

Murex antillarum Gabb, 1873, p. 202 (non *M. antillarum* Hinds, 1844).

Murex yaquensis Maury, 1917, p. 102(266), pl. 16(42), fig. 7, nom. nov. for *M. antillarum* Gabb not Hinds; Pilsbry, 1922, p. 353; Maury, 1925a, pl. 6, fig. 3.

[?] *Murex* cf. *yaquensis* Maury, Maury, 1925a, pp. 142–143, pl. 6, fig. 12.

[?] *Murex toreia* Maury, 1925a, pp. 144–145, pl. 6, fig. 11.

Murex (Murex) yaquensis Maury, Vokes, 1963a, p. 107.

[?] *Murex (Murex) toreia* Maury, Vokes, 1963a, p. 102, pl. 4, fig. 6 (Maury, 1925a, pl. 6, fig. 11).

Description.—

Shell broadly fusiform, whorls eight, rounded, varices three, small, having small, sharp spines variable in number; body whorl inflated, rounded in broadly to the suture, without any marked angle above, below tapering convexly to a nearly straight, short canal; spire elevated, about as long as the mouth, less the canal. Surface ornamented by numerous, more or less alternating, acute, revolving ribs, with concave outer spaces; crossing these are rather indistinct longitudinal ribs, four or five between each pair of varices. These ribs are better marked where they cross the revolving lines, than in the interspaces. Nuclear whorls polished, rounded, and without ornament. Aperture ovate, constricted in advance, canal about equal in length to that of the mouth proper. Inner lip expanded, showing transverse striations; outer lip more strongly striate internally. Length 1.15 in.; width 0.75 in.

A rare shell whose rounded form, thinner structure, more delicate varices and sculpture, and smaller size will all serve to distinguish it from the two preceding [*M. domingensis* Sowerby, 1850, and *M. recurvirostris* Broderip, 1833]. (Gabb, 1873, p. 202)

Diagnosis.—Muricid with inflated whorls and three varices per whorl, ornamented only by small open spines. Labium rugose entire length. Siphonal canal short, narrow, slightly deflected.

Lectotype.—ANSP 3255 (selected by Pilsbry, 1922, p. 353).

Type locality.—Locality TU 1227 (here restricted), Gurabo Formation; Arroyo Zalaya, which crosses the road to Jánico from Santiago de los Caballeros, 11 km south of the bridge over the Río Yaque del Norte at Santiago, Dominican Republic (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36).

Material.—Twenty-four specimens (most from loc. TU 1227), plus the Gabb material of seven specimens.

Measurements (in mm).—

specimen	height	diameter	locality
ANSP 3255 ¹	34.3	18.4	unknown
ANSP 3255A ²	42.0	23.0	unknown
PRI 28751 ³	33.8	17.2	? TU 1227 ⁴

¹ lectotype; ² paralectotype; ³ unfigured? paralectotype; specimen figured by Maury, 1917, pl. 42, fig. 7 — “metatype of Gabb’s *antillarum*”; ⁴ on the basis of matrix in the shell

Remarks.—With but a few exceptions (one example each from locs. TU 1292, 1451, and NMB 17267 [= loc. TU 1448]; see Saunders, Jung, and Biju-Duval, 1986, text-figs. 21, 29), all of the material of *Chicoreus (Siratus) yaquensis* has been collected along Arroyo Zalaya and it seems virtually certain that this is where Gabb’s specimens also came from; thus, locality TU 1227 is here restricted as the type locality. Certainly it is a place that Gabb would have been likely to collect, as Jánico is one of the oldest settlements in the country, having been founded by the Spanish as a fort in the very early days of the colony, and the road to Santiago has been in existence since that time.

Although essentially confined to this single locality, the species is not especially rare. Gabb had at least eight specimens (seven in the type lot at ANSP and one sent to the Paleontological Museum at Cornell University, Ithaca, NY, U. S. A.), and we have collected 24 examples. Arroyo Zalaya would seem to represent the deepest of all the fossiliferous exposures of the Gurabo Formation, as *Poirieria (Paziella) domingensis* (Gabb, 1873) is also found here.

Why Gabb should have cited the measurements of the smaller of his specimens for this species is a mystery. As Pilsbry (1922, p. 353) noted, there is an error in the published “length 1.15 in.,” which is probably a typographical error. The shell is 1.25 inches (34 mm) long. But the other specimen in the type lot (42 mm long, here figured as Pl. 3, fig. 7) is the largest seen; the

largest example in the TU collections is just over 40 mm long.

Maury (1925a, pl. 6, fig. 12) figured a fragmentary specimen from the Pirabas Limestone of Brazil, which she compared to *C. yaquensis*. It seems a reasonable assignment, as her illustration (refigured here, Pl. 3, fig. 9) shows an inflated shell with almost no varical spines. However, another species that she named at the same time (*Murex toreia* Maury, 1925a, p. 145, pl. 6, fig. 11) is even more like *C. yaquensis*, and almost certainly represents the same species. Her type is an external mold (refigured here, Pl. 3, fig. 10), but a casting made from it was compared with the specimens of *C. yaquensis* and there seems to be no discernible difference.

The modern descendant of this species is *Chicoreus* (*Siratus*) *ciboney* (Clench and Pérez Farfante, 1945). According to these authors, *C. ciboney* ranges from depths of 180 to 248 fm (330–454 m), corroborating the implied depth of the fossil specimens.

Comparisons.—This deep-water species is obviously ancestral to the living *Chicoreus* (*Siratus*) *ciboney*; the two share a similar type of protoconch and early whorls, as well as the short stubby siphonal canal. But *C. ciboney* has a coarser surface ornamentation, usually consisting of three axial ribs between each pair of varices. The axial ornamentation is stronger than the spiral and the surface lacks the beaded appearance of *Chicoreus* (*Siratus*) *yaquensis*.

The Maury 1916 Expedition did not get as far east as Santiago and so she had only Gabb's specimen to study, leading her to the erroneous conclusion that the species intergrades with *Chicoreus* (*Siratus*) *domingensis*. The two forms are superficially similar but *C. (S.) yaquensis* is much more inflated, the intervarical ribbing is more distinctly beaded, and the siphonal canal is shorter and more recurved at the distal end. Furthermore, although Maury may not have had the necessary material to observe this, the protoconchs of the two forms are markedly different (compare Pl. 3, fig. 8, and Pl. 4, fig. 4b). Especially characteristic are the approximately nine prickly little varices on the first two post-nuclear whorls (see Pl. 3, fig. 8) of *C. yaquensis*. All other species of *Murex* (*Haustellum*) and *Chicoreus* have rounded nodes.

Occurrence.—Gurabo Formation: Río Mao (TU 1292); Santiago area (TU 1227, 1451, 1453; NMB 17267).

Distribution.—Gurabo Formation, Dominican Republic. ?Pirabas Limestone, Brazil; early Miocene.

***Chicoreus* (*Siratus*) *eumekes*, new species**

Plate 3, figures 11, 12

Etymology of name.—Gr. *eumekes* = tall.

Description.—Shell with protoconch of three-and-

one-half conical whorls; seven post-nuclear whorls in the adult. Axial ornamentation beginning at a small, sharp varix, with twelve equal axial nodes. By third teleoconch whorl every third node strengthened to form a small varix. Three varices per whorl, with usually two intervarical nodes, rarely a smaller third added on adult body-whorl. In addition to the varices and nodes, the intervarical surface covered with minute axial growth lines. Spiral ornamentation of three to four cords on early whorls, gradually intercalating first a series of smaller threads between each pair of major cords, then a second series of even smaller threads between each major-minor pair, giving the typical three-fold muricine pattern of five (one large, one small, one medium, one small, one large) spirals for each pair of major cords. Seven or eight major spiral cords on body whorl, an additional five or six on the extended siphonal canal. Where the axial growth lines cross the spirals, small lamellar frills raised, especially on the varical faces. At the shoulder a small spine produced, and on the anterior half of the varix smaller spinelets, which tend to coalesce into a single laminar flange that extends about halfway along the siphonal canal. Aperture oval; inner lip standing free, especially at the anterior end, bearing elongated denticles along the entire length. Small anal notch formed by a larger denticle at the posterior end. Outer lip marked by 16 to 18, mostly paired, lirations that extend well into the aperture. Siphonal canal long, slightly curved at the distal end; previous canals diverging. Canal almost closed, but open by a narrow slit.

Diagnosis.—Muricid with very elongate shape and three varices on each whorl, these ornamented only by small spinelets. Labium rugose over its entire length. Siphonal canal long, broad, only weakly deflected.

Holotype.—USNM 323869.

Type locality.—Locality TU 1215, Gurabo Formation; Río Gurabo, bluffs on both sides, from the ford on the Los Quemados-Sabaneta road upstream to approximately 1 km above the ford, Dominican Republic (= locs. USGS 8539–8543; Maury's Zone D; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5).

Material.—A total of 19 specimens, the majority from locality TU 1215.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323869 ¹	44.9	19.8	TU 1215
USNM 323870 ²	14.6	7.0	TU 1215
PRI 33038 ³	51.0	23.6	TU 1215

¹ holotype; ² paratype; ³ unfigured paratype

Remarks.—*Chicoreus* (*Siratus*) *eumekes*, n. sp., is not especially rare, as it is known from 19 specimens. The fact that it is most common in the vicinity of locality TU 1215 (13 of the 19 specimens) suggests that

it inhabits shallower water than most Gurabo Formation species. Its nearest living relative is *Chicoreus* (*Siratus*) *consuela* (Verrill, 1950), which lives in depths from 70 to 100 m. But even more importantly, *C. consuela* usually is found in the vicinity of coral reefs; we have a number of specimens from the Pleistocene Moín Formation at Puerto Limón, Costa Rica (loc. TU 1240).

Comparisons.—Superficially *Chicoreus* (*Siratus*) *eumekes*, n. sp., most nearly resembles *Murex* (*Haustellum*) *pennae* Maury, 1925a, with which it occurs, but may be distinguished from it by the narrower shell shape, the recurved siphonal canal, and the multi-whorled conical protoconch.

The Dominican Republic species is almost certainly ancestral to the living *C. consuela* from which it may be distinguished by its less recurved canal and the protoconch, which in *C. consuela* has two-and-one-quarter bulbous whorls. The living species also has a smoother intervarical surface, lacking both the smallest spiral cords and the axial growth lines that give *C. eumekes* a much rougher texture.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1210, 1215, 1231; NMB 15807, 15858, 15863, 15867); Río Mao (TU 1293; NMB 16910); Santiago area (TU 1250).

Distribution.—Gurabo Formation, Dominican Republic.

Genus *PTERYNOTUS* Swainson, 1833

Pterynotus Swainson, 1833, expl. to pl. 100.

Type species.—*Murex pinnatus* Swainson, 1822, by subsequent designation, Swainson, 1833, pl. 122.

Subgenus *PTERYNOTUS sensu stricto*

Pterynotus (*Pterynotus*) *phyllopterus* (Lamarck)

Plate 5, figure 1

Murex phyllopterus Lamarck, 1822, p. 164; Kiener, 1843, p. 103, pl. 24, fig. 1; Cernohorsky, 1971, p. 189, fig. 5 (holotype).

Murex rubridentatus Reeve, 1846a, pl. 36, fig. 186.

Pterynotus (*Pterynotus*) *phyllopterus* (Lamarck). Emerson and Old, 1972, p. 350, figs. 1–6.

Pterynotus phyllopterus (Lamarck). Fair, 1976, p. 67, pl. 13, fig. 157 (holotype); Radwin and D'Attilio, 1976, p. 100, pl. 7, fig. 8.

M. testa oblonga, fusiformi, trialata, transversim sulcata, alba, roseo tincta; alis magnis, membranaceis, superne incisio-fimbriatis; interstitium costellis duabus tuberculiferis; apertura ovata-angusta; labro margine dentato. (Lamarck, 1822, p. 164)

Description.—

The shell of this recently rediscovered species is rather large (length about 80 mm) and trigonal. The spire is high, consisting of six or seven convex to barely subangulate postnuclear whorls and a protoconch of undetermined nature. The suture is indistinct. The body whorl is moderately large and trigonal. The aperture is smallish and

lenticular, with a narrow, moderately deep anal sulcus, and the entire aperture is oriented out of the plane of the outer apertural lip; the inner apertural margin is sunken relative to the outer apertural margin. The outer apertural lip is broadly flaring, weakly erect, and thrown into a series of broadly spaced short points or cusps; the inner surface of the outer lip, almost completely exposed at the outer apertural margin, bears a series of eight prominent tubercles, these decreasing in size anteriorly. The columellar lip is adherent and thinly callused, barely detached and nonerect at its anterior end. The siphonal canal is of moderate length, broad, barely open, and distally recurved.

The body whorl bears three broad, ruffled varices upswept posteriorly to fuse with the varix of the preceding whorl. The winglike flanges thus extend from the suture and from the fusion of the varix with a varix of a preceding whorl to the point near the tip of the canal at which the canal turns dorsally. Intervarical axial sculpture consists of two or three low ridges, these strongest at the shoulder margin and extending to about midway on the body. Spiral sculpture consists of a single weak cord on the shoulder, seven stronger cords on the body, and three strong cords on the canal, the cords corresponding to the dorsally upraised portions of the ruffled varical margin. (Radwin and D'Attilio, 1976, p. 100)

Diagnosis.—A large, elongate muricid with three undulating winged varices on each whorl, aligned in a straight line up the spire. Labium smooth, inner side of outer lip with strong denticles. Siphonal canal long, wide, only slightly deflected.

Holotype.—MHNG No. 1099/27 (Cernohorsky, 1971, p. 188).

Type locality.—Recent; Martinique (restricted by Emerson and Old, 1972, p. 552).

Material.—One specimen, USNM 323878, from the Gurabo Formation on Río Gurabo, locality TU 1231.

Measurements (in mm).—

specimen	height	diameter	locality
MHNG No. 1099/27 ¹	83.4 ²		(see above)
USNM 323878	45.4	21.8	TU 1231

¹ holotype; ² *vide* Cernohorsky, 1971, p. 188

Remarks.—One of the more exciting recent additions to the body of muricine knowledge was the discovery in 1972 that the beautiful species *Pterynotus* (*Pterynotus*) *phyllopterus*, previously assumed to be from the Indo-Pacific, was an inhabitant of the Windward Islands. As Emerson and Old (1972, p. 351) pointed out in their announcement of this discovery, the species is a descendant of the New World line of *P. burnsii* (Aldrich, 1894)—*P. postii* (Dall, 1896)—*P. hoerlei* Vokes, 1970b (all figured by Vokes, 1970b, pl. 2), a line previously thought to terminate with the lower Miocene *P. hoerlei*. Therefore, although it was a pleasant surprise to discover a Gurabo Formation specimen of *P. phyllopterus*, it was not the electrifying experience it might have been twenty years ago.

The Recent specimens from Martinique were taken from about 30 m depth, associated with coral massifs. Unfortunately, the exact locality of the Gurabo Formation specimen is not known as it was found as "float"

in the river gravel. But the association with corals suggests that locality TU 1215 is probably the true locality. Clearly the specimen has not "floated" too far. Corroborating the association with coral reefs is the heretofore-unreported occurrence of fragments of *P. phyllopterus* from the Caloosahatchee Formation of southern Florida (loc. TU 1175), also associated with a coral reef, and from the coralliferous Moín Formation of Costa Rica (locs. TU 954 and 1240).

Comparisons.—Other than the older species mentioned above, all of which lack the strongly upturned angle of the shoulder area that gives *P. phyllopterus* a more triangular aspect (although this is not visible in the battered specimen figured here), there is no other species, fossil or Recent, in the Western Hemisphere that may be compared with *P. phyllopterus*.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1231).

Distribution.—Gurabo Formation, Dominican Republic. Caloosahatchee Formation, Florida; Pliocene. Moín Formation, Costa Rica; Pleistocene; Windward Islands; Recent.

***Pterynotus (Pterynotus) aliculus*, new species**

Plate 5, figure 9

Etymology of name.—*L. aliculus* = little wing.

Description.—Shell with six teleoconch whorls in holotype; protoconch of one-and-three-quarters polished whorls, axis tilted, line of demarcation between proto- and teleoconch indicated only by change from highly polished to rough shell surface. Spiral ornamentation essentially lacking, only the faintest of threads, except on body whorl where three cords are visible on abaxial surface of varices. Axial ornamentation on first post-nuclear whorl of four simple varical flanges, reduced to three on second and all succeeding whorls; each varix consisting of a single plate of shelly material drawn out into (on the body whorl) five digitations, with edge curled forward between the digitations; varices aligned in an almost straight line up the spire. On earliest post-nuclear whorls two very faint nodes between each pair of varices, on later whorls increasing to three or four and becoming stronger; at the intersection with the three otherwise invisible spiral cords intervarical nodes forming distinct ball-like rounded knobs. Aperture ovate; inner lip smooth, free-standing, except for small portion at posterior end; outer lip weakly crenate, with a single denticle just anterior to the shoulder digitation. Siphonal canal short, narrow, strongly recurved so that former terminations diverge as spurs off to one side.

Diagnosis.—A small muricid with three winged varices, each with five strong spine-like digitations. Axial ridges marked by rounded nodes at intersection of spiral cords. Labium smooth. Siphonal canal short, narrow, recurved dorsally.

Holotype.—USNM 365141.

Type locality.—Locality TU 1215, Gurabo Formation; Río Gurabo, bluffs on both sides, from the ford on Los Quemados-Sabaneta road, upstream to approximately 1 km above the ford, Dominican Republic (= locs. USGS 8538–8543; Maury's Zone D; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5).

Material.—One specimen, USNM 365141, the holotype.

Measurements.—USNM 365141 (holotype); height 10.3 mm, diameter 5.4 mm; locality TU 1215.

Remarks.—Although based upon a single specimen, *Pterynotus (Pterynotus) aliculus*, n. sp., is so distinctive that there is no hesitation in naming it. Its nearest relative is the recently described species *Pterynotus (Pterynotus) xenos* Harasewych, 1982, which has a smaller, stouter shell, lacking the varical digitations of *P. aliculus*. In the description of *P. xenos*, it was noted by Harasewych (1982, p. 639) that the species has been confused with *Pterynotus tristichus* (Dall, 1889a) by Humfrey (1975, pl. 22, fig. 35) but the habitat of 60 to 70 m depth, associated with reef corals, was at variance with the normal habitat of *P. tristichus* (= *Pterynotus havanensis* Vokes, 1970b, new name), which is usually more than 200 m in depth.

Another species also recently described from the reefs off the northern coast of Jamaica, *Chicoreus (Chicoreus) cosmami* Abbott and Finlay, 1979, also has been taken at the coral reef at locality TU 1215, along with *P. aliculus*, n. sp., suggesting that the depth of water at that locality was 40–60 m.

Comparisons.—As noted above, *Pterynotus (Pterynotus) aliculus*, n. sp., is most closely related to *P. xenos*, which has a smaller, stouter shell and lacks the varical digitations. *Pterynotus xenos* has been confused with the deeper-water *P. havanensis* (which Harasewych and Jensen, 1979, consider to be a synonym of *M. phaneus* Dall, 1889a) and *P. aliculus*, likewise, has a superficial resemblance to this species. The most noticeable difference between the shallow-water and the deep-water species is the formation of the varices; in *P. xenos* and *P. aliculus* the varix is formed by a single flange of shell material, in *P. havanensis* and its allies the varix is composed of multiple layers of material and is markedly laminated. In all American species of *Pterynotus* the protoconch is approximately the same, varying from one-and-one-half to two smooth whorls, which are strongly tilted (see Harasewych and Jensen, 1979, fig. 16), and in characters other than the varical formation, all of the species appear much alike.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1215).

Distribution.—Gurabo Formation, Dominican Republic.

***Pterynotus (Pterynotus) neotripteris*, new species**

Plate 5, figures 2, 3

Etymology of name.—*L. neo* = new + *tripteris* = three-winged (in reference to the resemblance to the Indo-Pacific species *Murex tripteris* Born, 1778).

Description.—Shell with six or more post-nuclear whorls in adult, protoconch unknown. Spiral ornamentation of three strong cords on each whorl of the spire, smaller cords gradually intercalated; approximately 12 major cords on the body whorl, with an additional four major cords on the extended siphonal canal, numerous smaller intercalary threads. Axial ornamentation on early whorls of nine small equi-sized nodes, which gradually reduce to six nodes, then to three nodes and three varices per whorl. Varices formed by a series of overlapping, frilled laminae, the most abapertural of these extending as a wide flange. In addition to the varices, the entire shell surface covered with a series of lamellate growth lines, giving the surface a laciniate appearance. Suture extremely appressed, with a marked subsutural constriction. Aperture elongate, eight denticles on the inner side of the outer lip. Inner lip appressed at the posterior end, with a large adapical swirl but without denticulations, so far as known; anterior end standing free, bearing three or four denticles. Siphonal canal long, straight, only slightly recurved at the distal end; terminations of previous canals remaining as small spurs.

Diagnosis.—Muricid with three winged varices and a granulated surface. Labium rugose. Siphonal canal long, broad, recurved only at distal end.

Holotype.—USNM 323880.

Type locality.—Locality TU 1277, Gurabo Formation; Río Gurabo, both sides, upstream from the horse-trail to approximately 0.5 km above the trail, or approximately 2 km (airline) to 2.5 km above the ford on the Los Quemados-Sabaneta road, Dominican Republic (= Maury's Zone F; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 5).

Material.—A total of eight specimens, all from the shallow-water facies of the Gurabo Formation.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323880 ¹	40.2	18.0	TU 1277
USNM 323879 ²	24.6	12.2	TU 1219
PR1 33039 ³	39.7	17.0	TU 1250

holotype; ² paratype; ³ unfigured paratype

Remarks.—*Pterynotus (Pterynotus) neotripteris*, n. sp., is one of the rarer of the muricine species in the Dominican fauna; at present there are but eight specimens known. All are from the more shallow facies of the Gurabo Formation, including one from locality TU 1250, which was taken from the shallow-water gravity

flow (see *Introduction*; also Saunders, Jung, and Bijou-Duval, 1986, text-fig. 38). As the name suggests, the nearest living relative of this fossil species is the Indo-Pacific *Pterynotus (Pterynotus) tripteris* (Born, 1778), which is found in intertidal to subtidal depths.

Comparisons.—Other than the Indo-Pacific species *P. tripteris*, which has a much less elongate shell, this new species is most closely related to the European species *Murex granuliferus* Grateloup, 1833, of Tortonian age. The major difference between these two geographically separated forms is that the European species has a more shouldered shell and a relatively shorter canal (see Pl. 5, fig. 4). There is also a tendency toward having certain of the spiral threads bunched together, forming a series of heavier spiral cords. In contrast, in *P. neotripteris* all of the spiral cords are exactly the same size and distance apart.

In the Gurabo Formation fauna the only species with which *P. neotripteris* might be confused is *Chicoreus (Naquetia) compactus* (Gabb, 1873) (compare Pl. 3, fig. 2), but the two may be readily distinguished by the different apertures, with the posterior swirl and the anterior denticulations seen in *P. neotripteris*; *Chicoreus (Naquetia) compactus* has a simple free-standing columellar lip, with one large posterior tooth that forms an anal notch.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1211, 1231, 1277); Río Mao area (TU 1225); Río Amiana (TU 1219); Santiago area (TU 1250).

Distribution.—Gurabo Formation, Dominican Republic.

Subgenus *PURPURELLUS* Jousseaume, 1880

Purpurellus Jousseaume, 1880, p. 335.

Type species.—*Murex gambiensis* Reeve, 1845, by original designation.

***Pterynotus (Purpurellus) mirificus*, new species**

Plate 5, figures 10–12

Purpurellus sp. D'Attilio, 1985, p. 117, text-figs. 1, 2.

Etymology of name.—*L. mirificus* = causing wonder.

Description.—Shell with seven post-nuclear whorls in the adult. Protoconch of approximately one-and-one-half smooth, bulbous whorls. Exact line, however, between protoconch and teleoconch whorls not demarcated by any change except the onset of varices. Spiral ornamentation so faint as to be almost non-existent until about the fourth post-nuclear whorl where spiral threads gradually appear; on body whorl approximately eight weak spiral cords best seen on back side of varices, plus numerous very faint threads covering the entire surface of the shell. Axial ornamentation beginning after first one-and-one-half whorls with three small flange-like varices and continuing thus

hereafter; varices extending up the spire in a straight line. In addition to varices, axial ornamentation only of faint growth lines, together with the spiral threads giving a linen-like appearance to the shell surface. Varices composed of overlapping laminae, intricately looped on the adapertural face; at the shoulder of the whorl each varix with a wide wing-like projection formed by a folding over of the adapical edge of the varix, distal end recurved adapically also. Flanges of the varices not continuous onto the extended siphonal canal but confined to the body portion of the shell. On the siphonal canal only a single broad projecting process, remarkably curved back upon itself, from anterior edge to posterior edge. Aperture oval, entire, with a laminated, raised peristome. Siphonal canal long, straight, sealed over a plate-like extension of the columellar wall.

Diagnosis.—Small trivariolate muricid, each varix winged only at shoulder and along siphonal canal. Aperture entire, smooth. Siphonal canal long, straight, broad and sealed over.

Holotype.—USNM 323885.

Type locality.—Locality TU 1215, Gurabo Formation; Río Gurabo, bluffs on both sides from the ford on the Los Quemados-Sabaneta road upstream to approximately 1 km above the ford, Dominican Republic (= locs. USGS 8539–8543; Maury's Zone D; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 5).

Material.—Eighty-five specimens, almost all from locality TU 1215, or NMB equivalent localities.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323885 ¹	29.6	17.6	TU 1215
USNM 323883 ²	21.3 ³	17.0	TU 1215
USNM 323884 ⁴	13.5 ³	11.9 ³	TU 1215
PR1 33040 ⁵	17.6	12.0	TU 1215

¹ holotype; ² paratype A; ³ incomplete; ⁴ paratype B; ⁵ unfigured paratype

Remarks.—Although *Pterynotus* (*Purpurellus*) *mirificus*, n. sp., is not rare, as there are 85 specimens in the type lot, it is confined almost completely to locality TU 1215, where there are several unique species, including *Muricopsis praepaullus* (Maury, 1917) and *Lyria incompta* Hoerle and Vokes, 1978. Only a single specimen of *P. mirificus* has been taken from any other locality, this one from locality TU 1227A, which has the same distinct fauna (see *Introduction*).

The geographic distribution of *Pterynotus* (*Purpurellus*) is unusual, as it is known in the Recent fauna only from West Africa and West America. In the early Miocene of North Carolina is the only western Atlantic species hitherto known, *Pterynotus* (*Purpurellus*) *repetiti* Vokes, 1970b, and so the discovery of a second species in the western Atlantic is of more than usual

interest. *Pterynotus* (*Purpurellus*) is apparently another of the many paciphiles that have disappeared from the western Atlantic but survive in the eastern Pacific.

Comparisons.—As noted in a previous discussion of this subgenus (Vokes, 1970b, p. 16), the species of *Pterynotus* (*Purpurellus*) are so similar that all could be placed in synonymy with no great difficulty. Only the living West African species *Pterynotus* (*Purpurellus*) *gambiensis* (Reeve, 1845), type species of the subgenus *Purpurellus*, may be distinguished by its greatly expanded shoulder wing. *Pterynotus* (*Purpurellus*) *mirificus*, n. sp., is virtually a miniature of *P. gambiensis*, differing principally in being smaller; the largest specimen measures only 33 mm in height. The Recent shell is approximately twice this size, and also has a pronounced intervarical node lacking in the fossil species.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1215; NMB 15846, 15857, 15859, 15861, 15871, 16883, 16934); Santiago area (TU 1227A).

Distribution.—Gurabo Formation, Dominican Republic.

Genus POIRIERIA Jousseume, 1880

Poirieria Jousseume, 1880, p. 335.

Type species.—*Murex zelandicus* Quoy and Gaimard, 1833, by original designation.

Subgenus PAZIELLA Jousseume, 1880

Paziella Jousseume, 1880, p. 335.

Type species.—*Murex pazi* Crosse, 1869, by original designation.

Poirieria (*Paziella*) *dominicensis* (Gabb)

Plate 5, figure 7

Trophon dominicensis Gabb, 1873, p. 202; Guppy and Dall, 1896, p. 313; Vaughan and Woodring in Vaughan *et al.*, 1921, p. 147; Pilsbry, 1922, p. 354, pl. 28, figs. 2, 3 (lectotype).

Murex (*Trophon*) *wernerii* Toulou, 1911, p. 479, pl. 29, figs. 9a, 9b.

"*Trophon*" *dominicensis* Gabb [sic]. Woodring, 1928, p. 292.

"*Murex* (*Trophon*)" *wernerii* Toulou [sic]. Woodring, 1928, p. 292.

Paziella (*Dallimurex*) *dominicensis* (Gabb). Woodring, 1959, p. 217.

Paziella (*Dallimurex*) *wernerii* (Toulou). Woodring, 1959, p. 217.

Poirieria (*Paziella*) *dominicensis* (Gabb). Vokes, 1970b, p. 19, pl. 4, fig. 4.

Description.

Shell small, broadly fusiform, thin; spire three-fifths the length of the mouth, turriculated; whorls eight, the first three nuclear, round and increasing very little in width, the other five widening more rapidly and angulated. Body whorl truncated above, with a rounded rib on the angle; above this the surface sinuous, convex nearest the suture and concave adjoining the angle; below the angle it is convex in the middle and rounds concavely into a moderate canal. Surface marked by from six to seven blunt varices, each bearing a single spire [sic] on the angle of the whorl. Between the varices the surface is shallowly excavated. Crossing both the varices and interspaces, below the angle, there are a few small revolving ribs. Aperture bi-

angular posteriorly, narrowed gradually in advance; canal moderate in length, open; outer lip denticulated internally. (Gabb, 1873, p. 202)

Diagnosis.—Small muricid with six rounded varices per whorl, each with only one strong sharp spine at shoulder. Labium smooth. Siphonal canal moderately long, narrow, deflected dorsally.

Lectotype.—ANSP 3252 (selected by Pilsbry, 1922, p. 354).

Type locality.—Locality TU 1227 (here restricted), Gurabo Formation; Arroyo Zalaya, which crosses the road to Jánico from Santiago de los Caballeros, 11 km south of the bridge over the Río Yaque del Norte, at Santiago, Dominican Republic (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36).

Material.—A total of 26 specimens, all from the deeper-water facies of the Gurabo Formation.

Measurements (in mm).—

specimen	height	diameter	locality
ANSP 3252 ¹	17.5 ²	11.2 ³	TU 1227
USNM 323882	18.7	10.8 ⁴	TU 1227
PRI 33041	19.9	11.5 ⁴	TU 1227

lectotype; ² *vide* Pilsbry, 1922, p. 354; ³ including spines; ⁴ excluding spines

Remarks.—Among the Dominican muricids *Poirieria* (*Paziella*) *dominicensis* is not rare but is confined to the deeper-water facies of the Gurabo Formation, where there are 26 specimens from six localities. As discussed under *Chicoreus* (*Siratus*) *yaquensis* (Maury, 1917) [p. 50], Arroyo Zalaya is crossed by the road from Santiago to Jánico, which was in existence long before Gabb's time. This is also the only place where *P. (P.) dominicensis* might be said to be common, with 21 specimens from this locality; therefore, the type locality is here restricted to locality TU 1227.

In the USNM collections there is a specimen (USNM 113776) labeled *Trophon dominicensis* Gabb, which is stated to come from "Potrero, R. Amina", collected by "Bland?". Presumably this is the specimen upon which the Vaughan *et al.* (1921, p. 147) reference is based. As noted above under *Chicoreus* (*Chicoreus*) *corrugendum*, n. sp., other species on this list actually came from Baitoa; with the specimen of *P. dominicensis* this does not seem to be the case. Certainly the matrix present does not match that at Baitoa, nor does it match that at the Río Amina (loc. TU 1219; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 34). It is also not like that at Arroyo Zalaya where most of our specimens have been taken. The closest resemblance is to the deep-water beds on Río Verde (loc. TU 1251; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 38) where we also have taken the species. As

there is not a fragment of this species in either the Tulane or NMB collections from Potrero, I can only assume that the locality is probably in error but it is not possible to say with certainty what is the correct locality.

As noted previously (Vokes, 1970b, p. 20), *Murex wernerii* Toulou, 1911, from the Isthmus of Tehuantepec, Mexico, is a synonym of *Poirieria* (*Paziella*) *dominicensis*. The type locality of *Murex wernerii* is at "Kilometer 70 on the Trans-Isthmian Railroad." This locality (= loc. TU 1321) is still extant, and although no mollusks survive the years of weathering since the time of Toulou, calcareous microfossils are present in great abundance and give an age of N.20, Pliocene, according to Akers (1981, p. 146).

In a previous discussion (Vokes, 1970b), it was stated that the species attains a size of 30 mm, based upon the measurement of *Murex wernerii*. However, all the Dominican specimens are less than 20 mm but seem to be fully adult. This prompted a re-examination of Toulou's (1911, p. 479) original description of *Murex wernerii*. Although he stated that the height of the type is 30 mm, his illustration (1911, pl. 29, fig. 9) seems to be natural size (the spire measures 12.7 as stated) and measures 25 mm. Almost certainly the 30 mm is an error and 25 mm is probably the maximum size for this species.

Comparisons.—The Dominican Republic species is much more closely related to the living *Poirieria* (*Paziella*) *atlantis* (Clench and Pérez Farfante, 1945) (Pl. 5, fig. 6) than was previously recognized. The additional material now at hand shows that the only difference between the two species is the presence in *P. dominicensis* of a strong spiral cord at the shoulder, lacking in *P. atlantis*, plus the fact that the spines of *P. atlantis* are somewhat more upturned than those of *P. dominicensis*, which are almost at right-angles to the axis. The holotype (and sole example) of *P. atlantis* was described from 190 to 200 fm (345–363 m) off Cuba (Clench and Pérez Farfante, 1945, p. 41, pl. 21, figs. 3–5).

These two species differ from *Poirieria* (*Paziella*) *pazi* (Crosse, 1869), type of the subgenus *Paziella*, in that they do not have spines upon the siphonal canal. However, there are also other members of *Paziella* that lack these spines and they are not thought to be of taxonomic importance, although the subgenus *Bathymurex* was proposed by Clench and Pérez Farfante (1945, p. 41) for *P. atlantis*.

Occurrence.—Gurabo Formation: Río Mao (TU 1292); Santiago area (TU 1227, 1251, 1353, 1448, 1452; NMB 12721).

Distribution.—Gurabo Formation, Dominican Republic. ?Concepcion Inferior Formation, Veracruz, Mexico; Pliocene.

Subgenus **PANAMUREX** Woodring, 1959*Panamurex* Woodring, 1959, p. 217.

Type species.—*Murex gatunensis* Brown and Pilsbry, 1911, by original designation.

Poirieria (Panamurex) gabbi Vokes

Plate 5, figure 8

Trochoph? sp. Vaughan and Woodring in Vaughan *et al.*, 1921, p. 141.

Poirieria (Panamurex) gabbi Vokes, 1970b, p. 39, pl. 7, fig. 2.

Description.—

Nucleus unknown, seven post-nuclear whorls in the holotype. Axial ornamentation consisting of eight small varices on each of the first three post-nuclear whorls, decreasing then to seven on each of the succeeding whorls, including the last. Varices bearing small open spines only at the shoulder; where other major spiral ribs cross the varices only small ridges are formed. Spiral ornamentation of two ribs on the spire whorls with an intermediary thread appearing on the penultimate; six major spiral ribs on body whorl with three smaller riblets between that at the shoulder and the suture; a row of spines encircling the extended siphonal canal and one faint spiral rib between body and canal spines. Suture sigmoidal, rising up between varices and bending down at the varices. Aperture broken in holotype but at least three small denticles present at the anterior end of the inner lip. Nature of outer lip unknown but almost certainly denticulated; no labral tooth present. Siphonal canal open, moderately long, slightly recurved. (Vokes, 1970b, p. 39)

Diagnosis.—Muricid with seven varices per whorl, each ornamented by a single short open spine at shoulder. Labium with four rugae. Canal moderately long, recurved dorsally.

Holotype.—USNM 646084.

Type locality.—Locality USGS 8544, Gurabo Formation; right bank of Río Gurabo, about 150 m above middle ford at Gurabo Adentro, Monte Cristi, Dominican Republic (= loc. TU 1210; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 5).

Material.—Six specimens, all from the Gurabo Formation.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 646084*	24.7	14.3	USGS 8544
USNM 375461	41.9	22.4	TU 1412
PRI 33042	27.9	17.9	TU 1210

* holotype

Remarks.—*Poirieria (Panamurex) gabbi* remains rare; in addition to the holotype only four incomplete specimens have been taken in the vicinity of the type locality, plus the single large example figured here from the Río Guanajuma. These show the elongate denticulations predicted to be present on the inner side of the outer lip, as well as four denticles at the posterior end of the inner lip.

Comparisons.—Although this Dominican species

has, at first glance, a marked resemblance to certain living species of *Poirieria* (*Paziella*), the rugose labium instantly identifies members of the subgenus *Panamurex*. In this latter group the only species to which *P. gabbi* has more than a subgeneric affinity is the early Miocene species *Poirieria (Panamurex) fusinoides* (Gardner, 1947). The latter, from the Chipola Formation of Florida, differs in having a less inflated shell, with stronger spiral cords, and a longer, straighter siphonal canal.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1210, 1211); Río Amina area (TU 1412).

Distribution.—Gurabo Formation, Dominican Republic.

Subgenus **FLEXOPTERON** Shuto, 1969

Flexopteron Shuto, 1969, p. 111.

Type species.—*Flexopteron philippinensis* Shuto, 1969, by original designation.

Poirieria (Flexopteron) collata (Guppy)

Plate 5, figure 5

Murex collatus Guppy, 1873, p. 83, pl. 1, fig. 8 (reprinted in Harris, 1921, p. 215); Guppy, 1874, pp. 433, 438; pl. 16, fig. 8.

Muricea collata (Guppy). Dall, 1903, p. 1584.

"*Muricopsis*" *collatus* (Guppy) [sic]. Woodring, 1928, p. 291, pl. 17, figs. 10, 11 (holotype).

Paziella (Dallimurex) collatus (Guppy). Woodring, 1959, p. 217.

Poirieria (Flexopteron) collata (Guppy). Vokes, 1970b, p. 26, pl. 4, fig. 6 (paratype).

Description.—

Ovate, rimate, slightly flattened, adorned with numerous thin slightly fimbriate or crenulate varices often doubled, especially the later ones; about 7 on the last whorl; their interstices indistinctly crossed by low transverse costae which terminate in points on the varices; the upper point large, acute and projecting, giving an angulate appearance to the shell; varices uniting below to form an irregular and contorted canal. Whorls 6–7, somewhat angulate. Spire sharp. Outer lip expanded and crenulate, obtusely dentate within. Pillar-lip smooth. (Guppy, 1873, p. 83)

Diagnosis.—Moderately small muricid with about seven, thin flaring varices per whorl. Labium smooth, inner side of outer lip strongly denticulate. Siphonal canal short, broad, reflected dorsally.

Holotype.—USNM 115479.

Type locality.—Pleistocene; Bowden, Jamaica (= loc. TU 705).

Material.—Sixteen specimens, of which 15 are from the deep-water facies of the Gurabo Formation and one is from the Mao Formation.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 115479*	22	15	TU 705
USNM 323881	20.8	14.2	TU 1227
PRI 33043	20.4	14.6	TU 1227

* holotype

Remarks.—Although described from the Bowden Formation of Jamaica, there are several specimens of *Poirieria* (*Flexopteron*) *collata* from the Gurabo Formation, as well as a single example from the Mao Formation. All of the Gurabo Formation examples come from the deepest-water localities near Santiago. Considering that many of our specimens are from localities TU 1227 (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36) and TU 1250 (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 38), places mentioned above where Gabb certainly collected, it is surprising that he did not have this species.

So far as is known, the subgenus *Flexopteron* does not survive in the Recent fauna of the western Atlantic. There is but a single known living species of the group in the world, *Poirieria* (*Flexopteron*) *primanova*, described by Houart (1985, p. 166, fig. 3) from deep water off Madagascar. The average depth of specimens of this Recent species is 330 m, which agrees with the depths assigned to the localities at which *P. collata* has been taken.

Comparisons.—From the Miocene type species of the subgenus, *Poirieria* (*Flexopteron*) *philippinensis* (Shuto, 1969), the New World species differs in having fewer but stronger spiral cords (only five in contrast to the approximately 10 on the Philippine shell). The Recent species *P. primanova* has a more comparable spiral ornament but differs in having a much more produced open spine at the shoulder of each varical flange.

Occurrence.—Gurabo Formation: Santiago area (TU 1227, 1250, 1357, 1381; NMB 17271). Mao Formation: Los Quemados area (TU 1208).

Distribution.—Gurabo and Mao formations, Dominican Republic. Bowden Formation, Jamaica; Pleistocene.

Genus *ASPELLA* Mörch, 1877

Aspella Mörch, 1877, p. 24.

Type species.—*Ranella anceps* Lamarck, 1822, by monotypy.

Aspella castor Radwin and D'Attilio Plate 7, figure 12

Aspella castor Radwin and D'Attilio, 1976, p. 219, pl. 28, fig. 1; text-figs. 158 (shell), 159 (intritalcalx), 160 (radula).

Description.—

The shell is of moderate size for the genus (maximum length 13.4 mm) and lanceolate. The spire is high and markedly acute, and consists of one and one-third nuclear whorls and six or seven broad, flattened postnuclear whorls. The suture is impressed and obscured at intervals by narrow varical buttresses. The body whorl is of moderate size, broad, and flattened. The aperture is small and ovate, with a barely perceptible trace of an anal sulcus. The outer apertural

lip is weakly erect and bears five very weak denticles on its inner surface. The columellar lip is smooth, detached, and erect. The siphonal canal is moderately long for the genus, moderately open, bent to the left, and moderately dorsally recurved.

The body whorl bears four moderately broad lateral varices, the right ventral and left dorsal ones most prominent. Two moderately strong costae, representing the single ventral and dorsal varices seen on the first two or three postnuclear whorls, are apparent on the body whorl. Spiral sculpture is present only in the intritalcalx. Six broad cords with equal interspaces are apparent on the varices and become more apparent between the varices as the intritalcalx is eroded. The microsculpture of the intritalcalx is similar to that of *A. pollux* and *A. senex* in consisting of axial striae and numerous transverse tubes (see D'Attilio and Radwin, 1971, under *Aspella* cf. *A. pyramidalis*). (Radwin and D'Attilio, 1976, p. 219)

Diagnosis.—Small muricid with only two varices per whorl, aligned on opposite sides of the shell. Labium smooth. Siphonal canal short, narrow, slightly recurved.

Holotype.—USNM 663525.

Type locality.—Recent; Puerto Rico.

Material.—Four specimens, all from locality TU 1227A.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 663525*	13.0	5.9	(see above)
USNM 323895	9.1	4.3	TU 1227A

* holotype

Remarks.—Radwin and D'Attilio (1976) have separated the Antillean species of *Aspella* from the species in the Florida and Gulf of Mexico area, *Aspella senex* Dall, 1903. The latter was originally described as a fossil from the Pliocene beds of Florida but also occurs in the Recent fauna. The Antillean form was named *Aspella castor* in reference to its similarity to an eastern Pacific species much like it, which they named *A. pollux*.

Comparisons.—Radwin and D'Attilio (1976, p. 220) note that *Aspella castor* may be separated from *A. senex* by its more slender shell and more flattened body whorl. The first criterion is dubious, as *A. senex* exhibits a great variation in shell width. Those fresh examples that still possess the thick limy coating or intritalcalx may appear much wider, but the fossils, lacking this intritalcalx, in general seem to be more slender than *A. castor*. The two are also supposedly separable by the weaker denticulations on the inner side of the outer lip in *A. castor* but this is also extremely variable in *A. senex*; some have denticulations, some do not (compare the various examples figured by Vokes, 1975, pl. 1, figs. 1–4, 7).

Thus, I am not completely convinced that the two species are distinct; nevertheless the four examples of *Aspella* collected in the Dominican beds do appear to be different from those of Florida and Yucatan, and so the name *A. castor* is accepted.

Occurrence.—Gurabo Formation: Santiago area (TU 1227A).

Distribution.—Gurabo Formation, Dominican Republic, Puerto Rico and Virgin Islands; Recent.

Genus **DERMOMUREX** Monterosato, 1890

Dermomurex Monterosato, 1890, p. 181 (new name for *Powertia* Monterosato, 1884, non *Powertia* Bonaparte, 1840).

Type species.—*Murex scalarinus* Bivona-Bernardi, 1832 [= *Murex scalaroides* Blainville, 1829], by original designation.

Subgenus **DERMOMUREX** *sensu stricto*

Dermomurex (*Dermomurex*) **olssoni**, new species

Plate 7, figures 1–3

Aspella scalaroides [sic] (Blainville). Maury, 1917, p. 104(268), pl. 17(43), fig. 11 (not of Blainville, 1829).

Aspella scalaroides Maury not Blainville. Vaughan and Woodring in Vaughan *et al.*, 1921, p. 141.

Dermomurex (*Dermomurex*) *engonatus* (Dall). Vokes, 1975, p. 136 (in part, Dominican Republic reference only; not of Dall, 1892).

Etymology of name.—Named for the late Axel A. Olsson, in recognition of his work in the Dominican Republic.

Description.—Shell with six post-nuclear whorls in adult; protoconch of one-and-one-half bulbous turns. No spiral ornamentation until second post-nuclear whorl, then one faint cord at the periphery; by fourth post-nuclear whorl a second cord near the shoulder. On body whorl five or six broad rounded cords, the middle four always strongest. In addition, very faint spiral threads covering entire surface. Axial ornamentation of six or seven straplike varices on each of the first three post-nuclear whorls; by fourth whorl every other varix degenerating to an intervarical node; thereafter, three varices and three nodes per whorl. At intersection of spiral cords with both varices and intervarical nodes rounded knobs produced, those at the shoulder most prominent. Suture impressed; each intervarical node overlapping the suture as a buttress. Aperture oval; outer lip having within about nine strong denticles; margin crenulated, reflecting the spiral cords. Columellar lip smooth. Siphonal canal short, broad, recurved at distal end; open by a slit. In life the shell covered by a thick intritacalx usually lost in the fossil state, with only patches remaining.

Diagnosis.—Moderately small muricid with initially six varices per whorl, becoming three varices on later whorls. These rounded and ornamented only by crossing of spiral cords. Labium smooth. Siphonal canal short, broad, recurved dorsally.

Holotype.—USNM 323886.

Type locality.—Locality TU 1215, Gurabo Formation; Río Gurabo, bluffs both sides, from the ford on

Los Quemados–Sabaneta road upstream to approximately 1 km above the ford, Dominican Republic (= locs. USGS 8539–8543; Maury's Zone D; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5).

Material.—Nine specimens, all from the shallow-water facies of the Gurabo Formation.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323886 ¹	22.7	10.2	TU 1215
PRI 28765 ²	19.9	10.0	TU 1215
USNM 323887 ³	14.4	7.0	TU 1215

¹ holotype; ² paratype A; ³ paratype B

Remarks.—Although Vokes (1975, p. 136) previously referred Maury's *Aspella scalaroides* [sic] to the synonymy of *Dermomurex* (*Dermomurex*) *engonatus* (Dall, 1892), with the addition of more material it can be seen that the two are not the same. *Dermomurex* (*Dermomurex*) *olssoni*, n. sp., is indeed similar to *D. engonatus* but is shorter, more inflated, and lacks the sharp spine present at the shoulder of *D. engonatus*. The latter occurs in beds of Pliocene and Pleistocene age; the living representative (as noted in Vokes, 1976a, p. 45) is *Dermomurex* (*Dermomurex*) *alabastrum* (Adams, 1864).

The specimen figured by Maury (paratype A, Pl. 7, fig. 2) has a peculiar deformity in which there is an extra intervarical node between the second and third varices on the body whorl (with the aperture counted as number one). This results in the last two varices formed being offset one-half an intervarical space. The varices usually form a fairly straight line up the spire but this shell is 60 degrees out of phase on the body whorl. The holotype and the smaller paratype B show the more typical development.

Of the four species of *Dermomurex* in the Neogene beds of Dominican Republic, this is the most restricted. Primarily it occurs only along the Río Gurabo, above the bridge (loc. TU 1215; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5). There are six specimens from this locality in the TU collections, plus that of Maury. Another was taken by the NMB team. The only other example I have seen is from Cañada de Zamba (loc. TU 1354; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 15), where the facies is most nearly like that at locality TU 1215. The U. S. G. S. team is said to have collected a specimen at locality USGS 8544 (= loc. TU 1210; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5), according to Vaughan *et al.* (1921, p. 141), but this shell could not be located to verify the identification. In the dozens of juveniles of *Dermomurex* from locality TU 1227A (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36), none could be recognized as *D. olssoni*.

Comparisons.—There are three species of *Dermo-*

murex (*Dermomurex*) in the Dominican beds. All are similar and differences are a matter of degree. *Dermomurex* (*Dermomurex*) *olssoni*, n. sp., is marked by strong spiral cords in the intervarical area; *D. granulatus*, n. sp., has these cords nodulated, giving a granulated appearance to the intervarical area; *D. cracentis*, n. sp., is almost smooth in the intervarical area.

From the Plio-Pleistocene species *Dermomurex engonatus* and the Recent species *D. alabastrum*, as noted above, *D. (D.) olssoni*, n. sp., differs in being shorter, more inflated and lacking the shoulder spines. From the Mediterranean species *D. scalaroides* (Blainville, 1829), to which it was originally referred by Maury, it is readily separable by the different proportion of spire height to canal length; the spire being higher and the canal shorter in the latter form. The varices are also stronger in *D. olssoni* than in *D. scalaroides*.

Occurrence.—Gurabo Formation: Río Cana area (TU 1354); Río Gurabo (TU 1215; NMB 15858).

Distribution.—Gurabo Formation, Dominican Republic.

***Dermomurex* (*Dermomurex*) *granulatus*, new species**
Plate 7, figures 4–6

Etymology of name.—*L. granulum* = small seed (referring to surface ornamentation).

Description.—Shell with seven post-nuclear whorls, protoconch of one-and-one-half bulbous turns. Spiral ornamentation beginning on first teleoconch whorl with a single cord at the periphery, smaller cords progressively intercalated. The adult body whorl with six or seven indistinct flattened cords and numerous smaller intermediate threads. Axial ornamentation of six or seven straplike varices on early whorls; by fifth teleoconch whorl every other varix aborted, becoming an intervarical ridge; three varices and three ridges per whorl. Concurrently two small auxiliary axial ridges developing between each pair of the original varices, so that adult whorls show seemingly five small intervarical ridges between each pair of varices. At intersection of axial ridges and spiral cords small nodes produced; the five nodes on each of six or seven spiral cords resulting in a granulated appearance in intervarical areas. Suture deeply impressed, crossed by buttress-like structures at both remaining and aborted varices. Aperture oval, outer lip crenulated, having within about eight small denticles, decreasing in size from anterior to posterior. Inner lip smooth, polished, appressed at posterior end, standing free at anterior end, flaring over siphonal fasciole. Siphonal canal very short, recurved distally, giving rise to a strong fasciole. In life, shell covered with a heavy intritacal usually lost in the fossil state, remaining only as chalky patches.

Diagnosis.—Small muricid with initially six varices per whorl, diminishing to three per whorl. These

rounded and ornamented only by spiral cords, which are nodulated in intervarical areas. Labium smooth. Siphonal canal short, broad, recurved dorsally.

Holotype.—USNM 323889.

Type locality.—Locality TU 1296, Gurabo Formation; Río Gurabo, both sides, from 1 km above the horse-trail to the base of the formation, approximately 2 km above the trail, or about 3 to 4 km (airline) above the ford on Los Quemados–Sabaneta road, Dominican Republic (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5).

Material.—A total of 43 specimens (mostly juveniles from locality TU 1227A), from the shallow-water facies of the Gurabo Formation.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323889 ¹	15.4	7.4	TU 1296
USNM 323888 ²	16.2	10.0	TU 1212
USNM 323890 ³	7.5	3.7	TU 1215
PRI 33044 ⁴	14.3	7.0	TU 1227A

¹ holotype; ² paratype A; ³ paratype B; ⁴ unfigured paratype

Remarks.—In the shallower beds of the Gurabo Formation there are rare adult examples of a species of *Dermomurex* that I assume is ancestral to the modern species *Dermomurex* (*Dermomurex*) *pauperculus* (Adams, 1850). Like fossil examples of *D. pauperculus*, *Dermomurex* (*Dermomurex*) *granulatus*, n. sp., is extremely rare, presumably because of a comparable shallow-water habitat. The only place where we collected more than a single specimen is locality TU 1227A, a turbidity flow, which brought shallow-water material into the deep Gurabo facies. (This locality is discussed further on p. 16; see also Saunders, Jung, and Biju-Duval, 1986, text-fig. 36.) Here we have collected 38 specimens, almost all juveniles, as the material transported by the flow was all of a relatively small size.

Comparisons.—Morphologically, this species has the greatest resemblance to the French middle Miocene species *Dermomurex* (*Dermomurex*) *tenellus* (Mayer, 1869) (see Vokes, 1975, pl. 2, figs. 1, 2), in that the surface is covered by small granules. From *D. tenellus* the Dominican species may be distinguished by the extreme elongation in the early whorls of the French species. The proportion of spire height in relation to total shell height in *D. tenellus* is approximately 55%, in *D. granulatus* it is 44%. The overall shape of *D. pauperculus* is much the same as *D. granulatus*, the difference between the two being that *D. pauperculus* lacks the auxiliary intervarical nodes and, hence, the resulting granules.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1212, 1215, 1296; NMB 15860); Santiago area (TU 1227A, 1250).

Distribution.—Gurabo Formation, Dominican Republic.

Dermomurex (Dermomurex) cracentis, new species
Plate 7, figures 7, 8

Etymology of name.—*L. cracentis* = slender, graceful.

Description.—Five post-nuclear whorls in holotype; protoconch of one-and-one-half bulbous whorls. Spiral ornamentation on early teleoconch whorls of a single flattened cord at the periphery; by the third whorl several flattened threads both above and below this cord. On the adult body whorl one additional stronger cord posterior and two anterior to the original, for a total of four stronger cords, plus numerous flattened threads between them; overall aspect one of smoothness in the intervarical areas. Axial ornamentation of six straplike varices on each of the first four teleoconch whorls, by the fifth whorl alternate varices weakened to intervarical ridges. On holotype all varices except terminal reduced. Each successive whorl well below the preceding, giving rise to a deeply impressed suture, crossed by buttress-like structures at all varices both remnant and remaining. Aperture elongate-oval; outer lip flared at anterior end, non-denticulate within; inner lip smooth, appressed at posterior end, widely flaring at anterior end. Siphonal canal long, distally recurved, causing a strong fasciole. In life, shell covered with a heavy intritacal, usually lacking in fossil state, except for chalky patches.

Diagnosis.—Small muricid with initially six varices per whorl, diminishing to three or even one; intervarical areas marked by only weak spiral cords. Both labium and labrum smooth. Siphonal canal relatively long (for the group), narrow, recurved dorsally.

Holotype.—USNM 323891.

Type locality.—Locality TU 1219, Gurabo Formation; Río Amina, bluff on east side of river, just above the ford, which is 2 km west of Potrero, and about 3 km downstream from "La Represa", Dominican Republic (= loc. USGS 8516; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 34).

Material.—Fifteen specimens, all from the Gurabo Formation (most from locality TU 1227A).

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323891 ¹	14.9	6.9	TU 1219
USNM 323892 ²	8.6	4.0	TU 1227A
PRI 33045 ³	11.7	5.5	TU 1449

¹ holotype; ² paratype; ³ unfigured paratype

Remarks.—In the Gurabo Formation there are rare specimens of a species of *Dermomurex* that is unlike any New World species known today. It is more elongate and graceful than any other member of the group,

with the exception of a species only recently described from the Balcambian (middle Miocene) of southern Australia: *Dermomurex (Dermomurex) garrardi* Vokes, 1985 (p. 49, pl. 1, figs. 1–4).

Dermomurex (Dermomurex) cracentis, n. sp., probably inhabited slightly deeper water than the other two contemporary species of *Dermomurex*. The only examples have come from localities TU 1219 or TU 1449. A few came from locality TU 1227A (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36), but at the latter locality juveniles of *D. granulatus*, n. sp., greatly outnumber those of *D. cracentis*.

Comparisons.—The morphological similarities between *D. (D.) cracentis*, n. sp., and the Australian species *D. garrardi* are striking and one can only wonder at the true relationship. The Australian form is smoother in the intervarical areas, lacking all but the faintest of spiral cords; but the comparable elongation and the lack of labral denticles (not seen in any other American species of *Dermomurex*) cast doubt upon simple convergence. As noted in the description of *D. garrardi*, the only living species that seems to have more than a generic similarity is *Dermomurex (Trialatella) neglecta* (Habe and Kosuge, 1970), which has the expanded varical flanges of the subgenus *Trialatella* Berry, 1964. These ephemeral extensions of intritacal are rarely preserved in the fossil record and so both the Australian and the Dominican species may have had them to a greater or lesser degree. In any case, this is the only living species to which the Dominican form appears to be related.

Among New World species, *D. cracentis* is nearest to *D. granulatus*, n. sp., in overall shell shape, but may be distinguished by the smooth shell surface and lack of labral denticles. The anterior canal of *D. cracentis* is elongated in the manner of *D. olssonii*, n. sp., but otherwise there is little similarity.

Occurrence.—Gurabo Formation: Río Amina (TU 1219); Santiago area (TU 1227A, 1449).

Distribution.—Gurabo Formation, Dominican Republic.

Subgenus TRIALATELLA Berry, 1964

Trialatella Berry, 1964, p. 149.

Type species.—*Trialatella cunninghamae* Berry, 1964, by original designation.

Dermomurex (Trialatella) pteryonoides, new species
Plate 7, figures 9–11

Etymology of name.—Resembling the genus *Pteryonotus* [Gr. *ptery* = winged + Gr. *notos* = back].

Description.—Eight whorls in the adult, including a protoconch of approximately two bulbous whorls, exact line of transition between proto- and teleoconch impossible to ascertain. Axial ornamentation on early

post-nuclear whorls developed primarily in the intritacalx, usually lost in the fossils; the permanent ornamentation extremely faint, consisting of six small varices that lap onto the previous whorl. On third and successive post-nuclear whorls three flanged varices per whorl, perfectly aligned along the spire. Only a slight buttressed node across the suture suggesting the presence of the former alternating varices. Varices simple, consisting of a thin free-standing flange, best developed along the anterior canal. Spiral ornamentation also weak, consisting of numerous very fine threads covering the entire surface, superimposed upon five faint spiral cords on the body whorl. Apertural face of the varices mirroring these five spiral cords. In life the shell covered by a thick intritacalx, which undoubtedly increased the surface ornamentation and extended the varices, almost invariably lost in the fossil (only paratype B, a juvenile, retains most of this coating). Aperture oval, inner lip smooth, free-standing at the anterior end, slightly appressed at the posterior end; inside of outer lip with approximately eight very weak denticles. Siphonal canal moderately long, almost straight, recurved only at distal end.

Diagnosis.—Small muricid with initially six varices per whorl, diminishing to three on later whorls, each with flanged extension. Labium smooth. Siphonal canal moderately long, narrow, recurved dorsally.

Holotype.—PRI 30013.

Type locality.—Cercado Formation, Zone I, Río Cana (? = loc. TU 1282; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 15).

Material.—Two adult specimens, plus 12 juveniles; most from shallow-water facies of the Gurabo Formation, two from the Cercado Formation.

Measurements (in mm).—

specimen	height	diameter	locality
PRI 30013 ¹	20.0	9.6	Zone I, Río Cana ²
USNM 323893 ³	12.0	5.7	TU 1227A
USNM 323894 ⁴	9.4	4.9	TU 1227A

holotype; ² of Maury, ? = loc. TU 1282; ³ paratype A; ⁴ paratype B

Remarks.—In the Maury Collection now at the PRI, there is a beautiful specimen of *Dermomurex* (*Trialatella*), which for some unknown reason Maury chose to ignore. Upon cleaning it proved to be a new species most closely related to *Dermomurex* (*Trialatella*) *antecessor* Vokes, 1975, from the Pleistocene beds of Costa Rica and Florida. From the latter, *Dermomurex* (*Trialatella*) *pterynoides*, n. sp., may be distinguished by the earlier development of only three varices, which are perfectly aligned along the spire, in contrast to the random arrangement seen in the younger form. This latter feature is the single most obvious feature of the species, mimicking the only distantly related genus *Pterynotus*, and suggesting the trivial name.

From all evidence the Dominican occurrences of *Dermomurex* (*Trialatella*) *pterynoides* are in relatively shallow water. Maury's Zone I, Río Cana (? = loc. TU 1282; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 15), is in the Cercado Formation; our only other large specimen is from locality TU 1250, the Cercado facies turbidity flow into the Gurabo Formation at Río Verde, discussed in the *Introduction* (see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 38). All other examples, both the TU and NMB collections, are tiny shells, which could easily wash downslope into the adjacent Gurabo Formation.

The representative of the subgenus in the Pleistocene of Florida and Costa Rica, *D. antecessor*, is probably most closely related to *Dermomurex* (*Trialatella*) *oxum* Petuch, 1979, described from off the coast of southern Bahia, Brazil. This latter species is associated with coral patch-reefs, the author noting that the shells were collected at the base of these reefs and apparently had lived "cryptically in cracks and crevices in the reef" (Petuch, 1979, p. 517), rolling down the reef face after death. It is probable that *D. antecessor*, which is also associated with patch-reefs, similarly rolled down into the adjacent calcareous mud to be buried.

Comparisons.—As noted above, this new species differs from its presumed Pleistocene descendant, *Dermomurex* (*Trialatella*) *antecessor* Vokes, in the perfect alignment of the varices on the spire. Only *Dermomurex* (*Trialatella*) *jani* (Bellardi, 1872), from the Pliocene of Italy also has the varices so aligned and it differs from the Dominican species in having much stronger intervarical nodes and spiral ornamentation. The living *D. oxum* is more inflated and more heavily ornamented, in addition to not having the varices in alignment.

Occurrence.—Cercado/Gurabo formations: Río Cana area (NMB 16818, 16838); Río Gurabo (NMB 15838, 15846, 15849, 15860, 15863); Santiago area (TU 1227A, 1250).

Distribution.—Cercado and Gurabo formations, Dominican Republic.

Genus *ATTILIOSA* Emerson, 1968

Attiliosa Emerson, 1968, p. 380.

Type species.—*Coralliophila incompta* Berry, 1960 [= *Peristernia nodulosa* Adams, 1855b], by original designation.

Attiliosa aldridgei (Nowell-Usticke)

Plate 6, figures 9, 10

Vasum aldridgei Nowell-Usticke, 1969, p. 18, pl. 4, no. 834.

Attiliosa aldridgei (Nowell-Usticke). Nowell-Usticke, 1971, p. 11, pl. 2, no. 680; Vokes, 1976b, p. 124, pl. 8, figs. 9–11; Radwin and D'Attilio, 1976, p. 25, pl. 28, fig. 5; Vokes and D'Attilio, 1982, p. 69, figs. 6–9.

Description.—

A smallish, solid, pointed, whitish shell of about 7 whorls, with concavely sloping shoulders, and 6 or 7 strong, swollen rounded varical ribs on the body whorl. On the spire just above the suture, the top of each rib is ornamented with 2 short, raised, horizontal orange lines; on the body whorl, in addition to these 2 raised horizontal orange lines on the periphery, there are 2 more short horizontal lines below the middle, and a weak orange patch on the base.

The body is covered with faint spiral ribbing. There is a smooth white callus on the parietal wall, with two weak columella folds low down. The mouth is smoothly rounded, and has 6 teeth inside the outer lip. The siphonal canal is straight, and the base recurved. (Nowell-Usticke, 1971, p. 11)

Diagnosis.—Moderately small muricid with about seven ridge-like varices per whorl. Labium with about four small rugae at anterior end. Siphonal canal short, broad, recurved dorsally.

Holotype.—AMNH 189620.

Type locality.—Recent; Rat Island, Antigua, B. W. I.

Material.—A total of 13 specimens, from the coralline facies of the Cercado and Gurabo formations.

Measurements (in mm).—

specimen	height	diameter	locality
AMNH 189620 ¹	29.4 ²	20.0 ²	(see above)
PRI 30012	20.2	13.0	Zone D, Río Gurabo ³
USNM 365144	23.0	14.5	TU 1422

holotype; ² *vide* Emerson, written commun., 1979; ³ of Maury = loc. TU 1215

Remarks.—*Attiliosa aldrigei* has not been known from the fossil record before but we have collected 12 examples at two coral-reef localities, on the Río Gurabo and Arroyo Bellaco. Moreover, in the Maury Collection, now at the PRI, there is a large specimen (here figured), which was mixed in with a box of *Vasum gurabicum* Maury, 1917, from Maury's Zone D, Río Gurabo. Our largest example measures 31.5 mm in height, but it is not in the best condition.

As noted in a previous discussion (Vokes, 1976b, p. 124), the habitat of the living members of this species is coral reefs and the only localities where we have taken the fossil examples are also coral reefs. In the TU collections there is also a specimen of *A. aldrigei* from the Moín Formation (loc. TU 1240) of Costa Rica, which was associated with coral "patch-reefs" and a juvenile from the coralline facies of the Bermont Formation (loc. TU 727) of southern Florida.

In a study of the genus *Attiliosa*, Vokes (1976b) observed that *Attiliosa striata* (Gabb, 1873) was the oldest known member of this group. Since then *A. striata* has been transferred to *Acanthotrophon* Hertlein and Strong, 1951 (see p. 72), but the discovery of *Attiliosa aldrigei* in the Dominican Republic means that the genus is still first known in the New World from the Gurabo Formation. However, the genus has a much longer history than previously thought. In the Stam-

pian beds of Gaas, France, there is a species that is often identified in collections as *Turbinella muricina* Grateloup, 1847 (unnecessary new name for *Fusus turbinelloides* Grateloup, 1833). However, the latter name is correctly applied to another species from the same beds, *Murex (Poirieria) corniculatus* Verneau, 1963 (p. 78, fig. 5), which is (as was discussed by Vokes, 1970b, p. 6) a species of the subgenus *Panamurex* Woodring, 1959, most closely related to *P. lychnia* (Gardner, 1947). The unnamed species (here figured, Pl. 6, fig. 11) is almost identical to *A. aldrigei*. Thus, the scheme of development involving the subgenus *Panamurex*, which I suggested previously (Vokes, 1976b, p. 103), is obviously incorrect. Clearly, the genus *Attiliosa* is extremely ancient and begins, so far as known, in the Old World. In addition to the unnamed Stampian species, there is another form named as *Taurasia sacyi* by Cossmann and Peyrot (1923, p. 257, pl. 13, figs. 31, 32) from the Burdigalian of Aquitaine. The latter is probably the same species as that figured by Bellardi (1872, p. 146, pl. 9, fig. 20) as *Fusus villae* Michelotti, 1847, from the Tortonian of Italy. As observed previously (Vokes and D'Attilio, 1982, p. 69) this may or may not be the same as Michelotti's species (Michelotti, 1847, pl. 10, fig. 11), but, in any case, there are at least two and possibly even three species of *Attiliosa* in the Miocene of France and Italy. And, as predicted in the same paper, it is now clear that the connection between the Atlantic and Pacific species of *Attiliosa* extends back to the Tethyan seaway.

Comparisons.—In the Recent fauna the other members of this small genus, which was monographed by Vokes and D'Attilio (1982), are readily separable from *Attiliosa aldrigei*. Only the two European forms mentioned above have more than a generic similarity: *Attiliosa sacyi* (Cossmann and Peyrot, 1923) has only three spiral cords rather than the four of *A. aldrigei*; *Attiliosa* sp. from Gaas, France, has the spiral cords more subdued, not as scabrous as in *A. aldrigei*, and approximately eight in number.

Occurrence.—Cercado/Gurabo formations: Río Cana area (TU 1422); Río Gurabo (TU 1215).

Distribution.—Cercado and Gurabo formations, Dominican Republic. Moín Formation, Costa Rica; Bermont Formation, Florida; Pleistocene. Western Atlantic, the Bahamas to Panama; Recent.

Subfamily MURICOPSINAE Radwin and D'Attilio, 1971

Genus MUREXIELLA Clench and Pérez Farfante, 1945

Murexiella Clench and Pérez Farfante, 1945, p. 49.

Type species.—*Murex hidalgoi* Crosse, 1869, by original designation.

Subgenus **MUREXIELLA** *sensu stricto***Murexiella (Murexiella) hidalgoi** (Crosse)

Plate 8, figure 1

Murex hidalgoi Crosse, 1869, p. 408; Crosse, 1871, p. 68, pl. 1, fig. 4. *Murex (Murexiella) hidalgoi* Crosse. Clench and Pérez Farfante, 1945, p. 50, pl. 26, figs. 1-4; Vokes, 1968, p. 106.

Favartia sp. Perrilliat, 1972, p. 81, pl. 40, figs. 3, 4.

Murexiella hidalgoi (Crosse). Fair, 1976, p. 48, pl. 19, fig. 266; Radwin and D'Attilio, 1976, p. 157, pl. 25, fig. 8, text-fig. 99 (radula).

T. brevissime fusiformis, parum crassa sed solidula, paululum translucida, unicolor, albida; spira sat elongata; sutura profunde impressa; anfr. 7½-8 sexvaricosi, primi subangulati, vix aut non spinosi, antepenultimus et penultimus varicibus in spinas totidem desinentibus et costulis minoribus, in interstitiis sitis, separatis impressis, et spinis quinquieseriatim dispositis et varicibus correspondentibus ornatis, serie prima spinarum subincurva, majore, e costa suturae magnis vicina oriunda; apertura ovata, parva, subintegra, intus laevigata, alba, in canalem longissimum, fere clausum, subrecurvum, utrinque sat breviter spinosulum desinens; pesist. albidum, subcontinuum, margine columellari laevigato, subarcuato, leviter prominulo, externo ad limbum subondoso, mox extus, occurso varicis, in alam aperturæ latitudinem superantem, et in interstitiis spinarum lineis undosis elegantissime sculptam producto. (Crosse, 1869, p. 408)

Description.—

The shell is of moderate size (maximum length 35 mm) and broadly fusiform. The spire is moderately high, consisting of two and one-half nuclear whorls and five strongly shouldered postnuclear whorls. The suture is moderately impressed. The body whorl is large and broadly fusoid. The aperture is subovate, its posterior margin flattened; the anal sulcus is imperceptible. The outer apertural lip is strongly erect and coarsely crenulate, its inner surface crenulate marginally, smooth within. The columellar lip is detached and erect. The siphonal canal is long, very narrowly open to the right, and dorsally recurved.

The body whorl bears five spinose varices. Intervarical axial sculpture is lacking. Spiral sculpture consists of five major cords on the body, these beginning at the shoulder margin, three more in the space between the body and the canal, and two others on the canal; minor cords alternate with the majors on the body. The major cords are very weakly marked in the intervarical spaces; over the varices, however, they are developed into long, narrow, foliaceous spines of equal length that are narrowly open on their leading edges. A webbing-like expansion of the varix extends to about one-half the length of the spines. Where they are extended into spines the major cords become transversely tripartite, with a single major, transverse ridge flanked on each side by a single minor ridge. The entire shell surface is covered with fine spiral threads and scabrous laminae. (Radwin and D'Attilio, 1976, p. 157)

Diagnosis.—Muricid with five or six varices per whorl, each with about five long digitations, extending from the spiral cords, and connected by a complex webbing. Labium smooth. Siphonal canal long, narrow, slightly recurved dorsally.

Holotype.—Collection of Patricio Paz of Madrid (Clench and Pérez Farfante, 1945, p. 51) now in the Madrid Museum (Dance, 1966, p. 297).

Type locality.—Recent; Guadeloupe, Lesser Antilles (restricted by Clench and Pérez Farfante, 1945, p. 51).

Material.—Six specimens, all from the Gurabo Formation.

Measurements (in mm).—

specimen	height	diameter	locality
Paz coll. unnumbered ¹	36 ²	27 ^{2,3}	(see above)
USNM 323900	18.3	11.4	TU 1211
PRI 33046	15.7	10.3 ³	TU 1277

¹ holotype; ² *fide* Crosse, 1869, p. 409; ³ including spines

Remarks.—Although not previously reported as a fossil, there are six specimens of *Murexiella (Murexiella) hidalgoi* from the Gurabo Formation. In addition, Perrilliat (1972, p. 81, pl. 40, figs. 3, 4) has figured a small specimen as *Favartia* sp. from the Santa Rosa beds of southern Veracruz, Mexico. Although she attributes this fauna to the "Miocene Agueguexquite Formation", the beds in the vicinity of Santa Rosa have been dated by Akers (oral commun., 1979) as N.17, or late Miocene. In addition, in the Tulane Collections from the Pleistocene Moín Formation of Costa Rica, there are several examples of *Murexiella hidalgoi* from two localities (locs. TU 954, TU 1240).

The species lives today at depths ranging from 140 to 350 m, and is most abundant at about 200 m. The paleoecologic implication of these figures is puzzling, for the localities where the Dominican fossil examples were found are in what we consider as the "middle-depth" facies of the Gurabo Formation (three are from loc. TU 1219; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 34), rather than the localities that represent deposition in deeper water. However, it is possible that the species has been forced into deeper water since the Mio-Pliocene.

Comparisons.—In the fauna of the western Atlantic there is no species that might be confused with *Murexiella hidalgoi*; only the eastern Pacific cognate, *Murexiella diomedea* (Dall, 1908) has the same type of straight spines, all other members of the genus having more recurved spines. The Pacific form differs from *M. hidalgoi* in having less elaborate webbing between the varical digitations and a relatively larger aperture.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1211, 1277); Río Amina area (TU 1219, 1412).

Distribution.—Gurabo Formation, Dominican Republic. Santa Rosa beds, Veracruz, Mexico; late Miocene. Moín Formation, Costa Rica; Pleistocene. Gulf of Mexico and Lesser Antilles; Recent.

Murexiella (Murexiella) macgintyi (Smith)

Plate 8, figure 11

Murex macgintyi Smith, 1938, p. 88, pl. 6, fig. 11.

Murex (Favartia) macgintyi Smith. Clench and Pérez Farfante, 1945, p. 52, pl. 27, figs. 1-4; Olsson and Harbison, 1953, p. 246, pl. 36, fig. 5.

Murexiella (Murexiella) macgintyi (Smith). Vokes, 1968, p. 112, p. 7, fig. 3 (holotype).

Murexiella macgintyi (Smith). Fair, 1976, p. 55, pl. 20, fig. 278 (holotype; not *M. laurae* Vokes, 1970a, as stated in pl. expl.); Radwin and D'Attilio, 1976, p. 159 (in part), pl. 25, fig. 11 only.

Description.—

Whorls five, plus smooth shining nucleus of about two whorls, suture impressed; about seven spiral raised ridges with slightly branching terminations which are recurved, hollow inside near the tips; aperture moderately large, oval in shape; canal slightly oblique, partially closed, recurved at terminus.

This species is allied to *M. glyptus* Smith [1938]. One very characteristic feature is the pinched appearance of the posterior portion of the body whorl. Beyond this pinched portion is a pair of axial ridges which are somewhat separated from the others. (Smith, 1938, p. 88)

Diagnosis.—Small muricid with a variable number of varices, usually about six or seven, per whorl; these ornamented by five extremely recurved foliaceous digitations. Labium smooth. Siphonal canal long, narrow, almost straight.

Holotype.—McGinty Collection, University of Florida, Gainesville, FL.

Type locality.—Caloosahatchee Formation; Clewiston, Hendry County, Florida.

Material.—One complete specimen and three fragments from the Gurabo and Cercado formations.

Measurements (in mm).—

specimen	height	diameter	locality
McGinty coll., unnumbered*	20.7	18.0	(see above)
NMB H 17004	10.3	4.3	NMB 16842

* holotype

Remarks.—Although represented by one complete specimen and two fragments from the Cercado Formation and one-half of a specimen from the Gurabo Formation, the presence of *Murexiella macgintyi* in the Dominican Republic is of special interest relative to beds in southern Florida where the species is moderately common. In the Florida section *M. macgintyi* is confined to the Caloosahatchee Formation (also occurring in the time-equivalent Waccamaw Formation of South Carolina). In the older Pinecrest and Jackson Bluff formations (N.20) the species present is *Murexiella macgintyi faceta* (Vokes, 1963b), which also occurs in the Agueguexquite Formation of Veracruz, Mexico. This probably is a reflection of slightly cooler water. The distinction between these formations and the overlying Caloosahatchee Formation is primarily one of slightly warmer water in the Caloosahatchee Sea. Presumably *M. macgintyi* evolved in the more tropical Caribbean and moved into Florida only when the temperature increased. In the early Pleistocene Berrmont Formation, *Murexiella graceae* (McGinty, 1940) is the species present. However, *M. macgintyi* survives

in the western Atlantic, principally in the vicinity of the Bahamas to Cuba.

Comparisons.—There are a number of similar appearing species of *Murexiella* sensu stricto in the western Atlantic and eastern Pacific faunas (cognate pairs figured in E. H. Vokes, 1984) and the Pacific equivalent of *M. macgintyi* is *M. humilis* (Broderip, 1833), which differs in having a more triangular outline (with the shoulder spine more extended) and slightly longer spines (see E. H. Vokes, 1984, pl. 2, figs. 5, 6). Other species in the western Atlantic, which have been confused with *M. macgintyi* by various authors, include *Murexiella hilli* Petuch, 1987, a larger, more massive form, nearest to *M. keenae* (see E. H. Vokes, 1984, back cover photo), and *Murexiella taylorae* Petuch, 1987, a smaller more widely shouldered form, nearest to *M. laurae* (see E. H. Vokes, 1984, pl. 2, fig. 10), descendants of *M. faceta* and *M. graceae*, respectively.

Occurrence.—Cercado/Gurabo formations: Río Cana (TU 1230; NMB 16842); Río Gurabo (TU 1358); Santiago area (TU 1227A).

Distribution.—Cercado and Gurabo formations, Dominican Republic. Caloosahatchee Formation, Florida; Waccamaw Formation, South Carolina; Pliocene. East and west Florida coasts, Bahamas to Cuba; Recent.

Subgenus **SUBPTERYNOTUS** Olsson and Harbison, 1953

Subpterynotus Olsson and Harbison, 1953, p. 246.

Type species.—*Murex textilis* Gabb, 1873, by original designation.

Murexiella (Subpterynotus) textilis (Gabb) Plate 9, figure 1

Murex, nearest to *M. pinnatus* Swainson. Moore, 1853, p. 131.

Murex (Pteronotus) textilis Gabb, 1873, p. 202; Dall, 1890, p. 142, pl. 9, fig. 4 (on pl. expl. p. 187, as *Pteronotus textilis*).

Murex textilis Gabb. Guppy, 1876, p. 522, pl. 29, fig. 1 (Moore's specimen).

Murex (Pteropurpura) textilis Gabb. Dall, 1892, p. 243; Pillsbry, 1922, p. 353, pl. 28, fig. 4 (holotype).

Murex (Subpterynotus) textilis Gabb. Olsson and Harbison, 1953, p. 247, pl. 36, figs. 7, 7a; Dubar, 1958, p. 197, pl. 11, fig. 8; Jung, 1965, p. 521, pl. 69, figs. 8, 10.

Murexiella (Subpterynotus) textilis (Gabb). Vokes, 1968, p. 120, pl. 8, figs. 1–3; Vokes, 1974b, p. 10, pl. 2, fig. 3.

Pterynotus (Subpterynotus) textilis (Gabb). Woodring, 1970, p. 433, pl. 63, figs. 18, 19.

Description.—

Shell compressed triangular; whorls eight, the first nuclear, the next three cancellate and showing little or no trace of varices, which show themselves on the next (fifth) distinctly for the first time, suture deep, caused by the great convexity of the whorls. Body whorl broad and flat above, then very convex near the top and tapering very gradually in advance. The three varices are thin at their bases, broad, acute and slightly recurved on the margin. Between each pair of varices

there is one large prominent node, placed longitudinally, too broad to be called a rib. The entire surface is covered by about a dozen revolving ribs, except on the faces of the varices, where corresponding grooves take their places. Crossing these, the lines of growth are developed into minute erect plates, placed at equal distances and arching over all the ribs and intermediate, alternating lines, so as to produce under a lens, the effect of a lace, or loosely woven web. Aperture small, ovate; inner lip acute; outer lip faintly grooved internally; canal about twice as long as mouth and nearly, or entirely arched over. (Gabb, 1873, p. 202)

Diagnosis.—Trivariate muricid, each varix forming a broad flange, extending the full length of body whorl and canal. Entire surface of shell covered with elaborate filigree. Labium smooth. Siphonal canal very long, broad, straight except at distal end.

Holotype.—ANSP 3257.

Type locality.—Locality TU 1364 (here restricted), Baitoa Formation; Boca de los Ríos, below the waterfall in Arroyo Hondo, which enters Río Yaque del Norte from the east, just below the confluence with the Río Bao, downstream from Baitoa, Dominican Republic (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 21).

Material.—Holotype and a single incomplete specimen from the Baitoa Formation.

Measurements.—ANSP 3257 (holotype); height 30.5 mm, diameter 16.0 mm; locality unknown.

Remarks.—Of all the muricids described by Gabb, *Murexiella* (*Subpterynotus*) *textilis* remains the most rare. A single broken specimen has been collected at locality TU 1364, and thus, the type locality is restricted to this place. Unfortunately, this is meaningless in terms of correlation, for the species is known in the western Atlantic from the early Miocene through the Pliocene, at which time it suddenly vanishes. The origin of the species is not known, but *Murex subgranifer* Cossmann and Peyrot, 1923, from the Aquitanian and Burdigalian of France, may be ancestral to both this species and the Italian species *Murexiella* (*Subpterynotus*) *granifera* (Michelotti, 1841), from the Helvetian and Tortonian.

Comparisons.—In the New World there is no species even remotely similar to *Murexiella* (*Subpterynotus*) *textilis*, so there is little chance of confusing it with any other form. As noted above, in the Miocene of France the species *Murexiella* (*Subpterynotus*) *subgranifer* (Cossmann and Peyrot, 1923, p. 99, pl. 17, fig. 34; pl. 18, fig. 2), has a slight similarity but differs in that the siphonal canal does not have a wide varical extension but has a more typically *Murexiella*-like straight canal with small spines along its length. The Italian species *Murexiella granifera* (Michelotti, 1841, p. 11, pl. 5, fig. 6), at least as figured by Bellardi (1872, pl. 5, fig. 1), does not show the expanded and recurved varices of the American form; but this may be the result of breakage. Many American specimens that have been brought

up by a dragline in southern Florida do not look greatly different. The Bellardi specimen, however, does seem to have a larger aperture than American ones of the same size.

As I have discussed in an earlier paper (Vokes, 1974b, p. 12), the only living species that in any way resemble *M. (S.) textiles* are *Murexiella* (*Subpterynotus*) *tatei* (Verco, 1895), from Australia, and *Murexiella exquisita* (Sowerby, 1904), which has yet to be localized. The Australian form differs in having six rather than three varices on the body whorl, but otherwise is little different. The second species, *M. exquisita*, was described without locality, and in the years since its description only one additional specimen has been discovered—a previously unknown paratype in the Dautzenberg Collection at the Institut Royal des Sciences Naturelles de Belgique, figured by Houart (1980, pl. 1A, figs. 1, 3). This elusive species differs from the Dominican Republic fossil in having a distinct spine at the shoulder, much like that seen in *M. subgranifer*, giving a more triangular appearance to the whorls. Except for this, the two are extremely similar. On the basis of other species described by Sowerby at the same time, the provenance of *M. exquisita* may be western Africa, but how nice it would be if some future collector rediscovered it in the western Atlantic, in the same manner as *Pterynotus phyllopterus* (see p. 52).

Occurrence.—Baitoa Formation: Baitoa area (TU 1364).

Distribution.—Baitoa Formation, Dominican Republic. Cantaure Formation, Venezuela; Chipola Formation, Florida; early Miocene. Gatun Formation, Panama; Pinecrest, Jackson Bluff and Caloosahatchee formations, Florida; Pliocene.

Genus HOMALOCANTHA Mörch, 1852

Homalocantha Mörch, 1852, p. 95.

Type species.—*Murex scorpio* Linné, 1758, by monotypy.

Homalocantha species

Plate 8, figure 10

Material.—Figured specimen (USNM 323899).

Measurements.—USNM 323899; height (incomplete) 15.4 mm, diameter (incomplete) 10.9 mm; locality TU 1249.

Remarks.—On the south coast of the Dominican Republic there is a small outcrop, perhaps 15 m in length, along the highway west of San Cristobal (loc. TU 1249). The sparse fauna has the appearance of that of the Gurabo Formation, as it was considered by Bermúdez (1949, p. 29), who observed: "A similar open-water marine fauna of Gurabo age has been found in Trujillo Province on the south coast of the Republic 8 km southwest of San Cristobal" (loc. H20001 of

Bermúdez, 1949, p. 44). However, this outcrop is not of Gurabo age, for Akers (oral commun., 1977) has dated the planktic foraminifera as N. 11 or middle Miocene.

In fact, there are just a few mollusk species in common with the Gurabo Formation, *Murex* (*Haustellum*) *messorius* Sowerby, 1841a, and *Typhis* (*Talityphis*) *alatus* Sowerby, 1850, being the only muricids. But the most exciting find at this locality is a fragmentary specimen of a genus that is primarily Indo-Pacific in distribution today, the peculiar *Homalocantha*. There are New World species of the genus living in the eastern Pacific — *Homalocantha oxyacantha* (Broderip, 1833) and *H. tortua* (Broderip in Sowerby, 1834); and in the Miocene of Florida — *H. crispangula* (Heilprin, 1886) and *H. calhounensis* (Vokes, 1968). Vokes (1968, pp. 107 and 110, respectively) placed the two latter taxa in *Murexiella*, and there is a strong resemblance to that genus. It is my opinion that the genus *Homalocantha* is derived from *Murexiella*; thus, the similarity of these early species to the ancestral form is to be expected.

All of the New World species remain very like the *Murexiella* morphotype but the presence in the living species of a purpuroid operculum, typical of *Homalocantha* but not *Murexiella*, separates the two genera. The type species of *Homalocantha*, the strange Indo-Pacific *Murex scorpio* Linné, 1758, has diverged a long distance from the ancestral type and there is a group of species found today in the Indo-Pacific that is centered around this typical morphotype. Thus, it would not be too unexpected to find a species of *Homalocantha* in the middle or even late Miocene of the western Atlantic, although the genus is now extinct in the region, but it is surprising that it is not the *Murexiella*-like morphotype but the typical Indo-Pacific form with spatulate varical digitations. On the basis of what remains of the shell, the San Cristobal specimen is most like *Homalocantha zamboi* (Burch and Burch, 1960), which lives in the Philippine Islands.

Unfortunately the specimen is much too poorly preserved to describe, but its affinities are so remarkable that attention should be drawn to its occurrence. The fauna at this locality is most unusual, and like that at Bowden, Jamaica, seems to be a mixture of shallow and deep inhabitants. The fauna is almost 100% gastropods, of which turrids are the vast majority, especially two species most like the eastern Pacific *Gemma hindsiana* (Berry, 1958) and the Atlantic *Gemma periscelida* (Dall, 1889a), respectively. But mixed with these are large pebbles and rare examples of *Neritina virginea* (Linné, 1758) and *Potamides suprasulcatus* (Gabb, 1873), both characteristic of brackish waters.

Occurrence.—Unnamed formation: San Cristobal area (south coast) (TU 1249).

Distribution.—Unnamed formation, Dominican Republic.

Genus MURICOPSIS

Bucquoy, Dautzenberg, and Dollfus, 1882

Muricopsis Bucquoy, Dautzenberg, and Dollfus, 1882, p. 19.

Type species.—*Murex blainvilliei* Payraudeau, 1826, by original designation.

Muricopsis praepauxillus (Maury)

Plate 8, figures 2, 3

Murex (*Phyllonotus*) *praepauxillus* Maury, 1917, p. 103(267), pl. 16(42), fig. 11; Vaughan and Woodring in Vaughan *et al.*, 1921, p. 141.

Description.

Shell with seven whorls, the first two [one-and-one-half] smooth, nuclear, later whorls with low crenate varices, six [five to seven] to a whorl, and three main, crenate ridges revolving around the periphery. The uppermost spiral of each trio carinates the whorl, and on crossing the varices forms short, hollow spines; aperture narrowly elliptical; canal open, somewhat reflexed; outer lip edged by the final fimbriated varix and bearing within five well-marked denticles. (Maury, 1917, p. 267)

Diagnosis.—Small muricid with about six low, ridge-like varices per whorl, each ornamented only by short open spinelets. Labium smooth or with one small knob at anterior end. Siphonal canal short, broad, almost straight.

Holotype.—PRI 28755.

Type locality.—Gurabo Formation; Zone D, Río Gurabo at Los Quemados, Dominican Republic (= loc. TU 1215; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5).

Material.—Over 80 examples, from the coralline facies of the Gurabo Formation and the Cercado Formation.

Measurements (in mm).—

specimen	height	diameter	locality
PRI 28755 ¹	12.5	7.2	Zone D, Río Gurabo ²
USNM 323896	13.2	7.3	TU 1215

¹ holotype; ² of Maury = loc. TU 1215

Remarks.—Maury named *Muricopsis praepauxillus* from Zone D (= loc. TU 1215) on the Río Gurabo and this is almost the only place it is found. However, it is not rare here; there are more than 70 specimens in the TU collections. The NMB team also collected a number of examples from this same area and in the USGS collections made by Vaughan and Cooke there are two specimens, the one listed from locality USGS 8538 (in Vaughan *et al.*, 1921, p. 141) and another from locality USGS 8540 (= loc. TU 1215).

The only other examples, not surprisingly, come from locality TU 1227A, where there are fragments, and

Arroyo Bellaco (loc. TU 1422), which has yielded three specimens. The small shell is easily overlooked as the average height is about 12 mm (including the type specimen; Maury's "16 mm" is an error). However, the form does get larger: one example from Arroyo Bellaco measures 21 mm.

Comparisons.—The name *Muricopsis praepauxillus* was given by Maury because of a superficial resemblance to the Recent West Coast species *Muricopsis pauxillus* (Adams, 1854). The principal difference between the fossil and Recent species is the nature of the protoconch, that of *M. pauxillus* being noticeably keeled (see Radwin and D'Attilio, 1976, text-fig. 108), but *M. praepauxillus* has a bulbous protoconch, of one-and-one-half whorls. Of *M. pauxillus*, Keen (1971, p. 525) has observed: "Restricted to the southern part of the Gulf of California, especially around Mazatlan, Mexico, under rocks at extreme low tides." The species, however, ranges farther south, as we have collected numerous examples from Barra de Navidad, Jalisco (loc. TU R-166), where it is common under stones at very low tide.

In the western Atlantic, *Muricopsis huberti* Radwin and D'Attilio (1976, p. 232, text-figs. 182, 183) was said by the authors to have a "substantial resemblance" to *M. praepauxillus*, the latter differing "in its less truncate siphonal canal, more impressed suture, and larger aperture." At the time of the description the authors did not have a specimen with a well-preserved protoconch but material collected subsequently by Danker Vink in Curaçao shows that the protoconch, although similar, is somewhat larger in *M. huberti* (0.8 mm vs. 0.6 mm in the fossil). Described from the Lesser Antilles (Grenada and St. Vincent) in depths from 0 to 5.5 m, *Muricopsis huberti* has now been taken by Vink at Curaçao in depths ranging from 0.5 to about 20 m.

Perhaps even more closely related to *Muricopsis praepauxillus* is another unnamed species that is presently known only from Jamaica and was figured by Humfrey (1975, pl. 16, fig. 1) as *Muricopsis* species. He adds (1975, p. 137) that specimens have been "collected live on the reef opposite the Silver Seas Hotel (Ocho Ríos) in about 15 feet . . . We have found no beach specimens." Humfrey reported the species from depths of 15 to 30 ft (4.5 to 9 m) and Vink has collected additional material at Discovery Bay and Ocho Ríos under coral at 12 m.

Unfortunately none of the material yet at hand is very good; as Humfrey noted, "most specimens are heavily encrusted with coralline growth" (1975, expl. pl. 16). But it seems likely, in view of the habitat, in association with coral reefs, in slightly deeper water than *M. huberti*, that this unnamed Jamaican species is the true descendant of *M. praepauxillus*, for the fossil

form must have been restricted to coralline environments. It has been taken only at coral-reef localities with none found at any of the non-reef localities in the Cercado Formation, where if it were living "under stones at low tide" it almost certainly should have been preserved.

Occurrence.—Cercado/Gurabo formations: Río Cana area (TU 1422); Río Gurabo (TU 1215; NMB 15849, 15859, 15861, 16934); Santiago area (TU 1227A).

Distribution.—Cercado and Gurabo formations, Dominican Republic.

***Muricopsis* species cf. *M. praepauxillus* (Maury)**

Plate 8, figure 4

Material.—Figured specimen (NMB H 17186).

Measurements.—NMB H 17186; height 15.0 mm, diameter 7.3 mm; locality NMB 16943.

Remarks.—In the NMB collections from the Baitoa Formation, just downstream from Boca de los Ríos, there is a single rolled specimen of *Muricopsis* that bears a strong resemblance to *Muricopsis praepauxillus* (Maury, 1917) but differs in certain details. Even on the badly worn specimen there appear to be relatively strong secondary spiral threads on the subsutural ramp, an area that does not have anything but very faint spirals in *M. praepauxillus*. Also, the three major spiral cords seem to be relatively less well-developed in this specimen than in typical *M. praepauxillus*.

It is not inconceivable that the specimen is referable to *M. praepauxillus*; there are other Gurabo Formation species found in the Baitoa Formation. However, the morphological differences visible in this shell warrant the uncertainty indicated in the assignment.

Occurrence.—Baitoa Formation: Baitoa area (NMB 16943).

Distribution.—Baitoa Formation, Dominican Republic.

***Muricopsis quisqueyensis*, new species**

Plate 8, figures 7–9

Etymology of name.—(Arawak) *Quisqueya* = the original Indian name for the island of Hispaniola (but better known today as the name of a local beer).

Description.—Shell with six teleoconch whorls and a protoconch of one-and-one-half rounded whorls, ending in a small, sharp varix. Spiral ornamentation beginning with two strong cords, numerous smaller threads gradually added, covering the entire surface of the shell including the major cords; the latter persisting to the body whorl, where a total of five major cords are developed, plus another two on the siphonal canal. Axial ornamentation beginning on first teleoconch whorl with seven or eight small varices, increasing to eight or nine on the adult whorls. Where spiral ornamentation crosses varices, short, sharp spines pro-

duced, their size relative to the size of the spiral cord; in addition, shell surface shagreened by intersection of numerous axial growth lines and spiral threads. Aperture elongate-oval, inner lip appressed at posterior end and slightly free-standing at anterior end, two small denticles on anterior half. Inside of outer lip with five strong denticles, corresponding to spaces between the spiral cords; that one just anterior to shoulder cord much the largest. Siphonal canal short, broad.

Diagnosis.—Small muricid with eight or nine indistinct ridge-like varices, each ornamented with only very small open spinelets. Labium with two small denticles at anterior end, labrum strongly denticulate. Siphonal canal short, broad, almost straight.

Holotype.—USNM 365146.

Type locality.—Locality TU 1215, Gurabo Formation; Río Gurabo, bluffs on both sides from the ford on Los Quemados-Sabaneta road, upstream to approximately 1 km above the ford, Dominican Republic (= locs. USGS 8539–8543; Maury's Zone D; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 5).

Material.—Twenty specimens, all from the shallow-water facies of the Gurabo Formation.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 365146 ¹	14.5	7.0	TU 1215
USNM 365148 ²	13.2	7.4	TU 1215
USNM 365147 ³	11.7	6.9	TU 1215
PRI 33047 ⁴	12.2	5.6	TU 1215

¹ holotype; ² paratype B; ³ paratype A; ⁴ unfigured paratype

Remarks.—Occurring together with *M. praepauxillus* is another small species that may be confused with it. *Muricopsis quisqueyensis*, n. sp., is not so abundant as is *M. praepauxillus*. The type lot contains only 20 specimens, of which 15 are from locality TU 1215. The other localities, as might be expected, are the two shallow-water gravity-flows on the Río Verde (loc. TU 1250) and Arroyo Zalaya (loc. TU 1227A).

Comparisons.—*Muricopsis quisqueyensis*, n. sp., differs from *Muricopsis praepauxillus* in being more biconic in outline, with the shoulder less angulate and the siphonal canal less well demarcated from the body whorl; the varices are more numerous; the spiral ornamentation is more diffuse and the major spiral cords number five, not three; the species has the denticles typical of *Muricopsis* on the inner lip, which are lacking in *M. praepauxillus*. In many ways this new species is more akin to the West Coast species *Muricopsis pauxillus* than is its namesake, but such are the vagaries of nomenclature. From *M. pauxillus* the new species differs in having less pronounced varices, with the major cords less well developed. The protoconch is rounded rather than keeled, as in *M. pauxillus*.

Occurrence.—Gurabo Formation: Río Gurabo (TU

1215); Santiago area (TU 1227A, 1250).

Distribution.—Gurabo Formation, Dominican Republic.

Genus MUREXSUL Iredale, 1915

Murexsul Iredale, 1915, p. 471.

Type species.—*Murex octogonus* Quoy and Gaimard, 1833, by original designation.

Remarks.—Ponder (1972, p. 237) has suggested that *Muricopsis* Bucquoy, Dautzenberg, and Dollfus, 1882, and *Murexsul* should be considered synonyms because they both have the same type of radula, with the three-dimensional rachidian tooth of the subfamily Muricopsinae. In earlier papers, Vokes (1964, p. 13; 1968, p. 87) considered *Murexsul* as a subgenus of *Hexaplex* Perry, 1810, because of similarities in shell characters. Following that, Ponder (1968, p. 31) suggested that *Murexsul* should be placed in the Tritonaliinae (= Ocenebrinae), stating that Hutton's drawing of the radula was "misleading as it does not show the central tooth laying flat." Unfortunately, his illustration (Ponder, 1968, pl. 1, fig. 1) looks no different from the previous ones and so it was not until Radwin and D'Attilio (1971) proposed the subfamily Muricopsinae that the nature of the radula was made explicit. As I had come to the same conclusions regarding the subfamilial separation from the point of view of geologic history (see Vokes, 1971, p. 47), I readily accepted the creation of this new subfamily, which would include *Muricopsis*, *Murexsul*, *Murexiella* Clench and Pérez Farfante, 1945, *Favartia* Joussemae, 1880, and other genera with the three-dimensional rachidian tooth.

The differences between *Murexsul* and *Muricopsis* are somewhat subjective, more a matter of degree than extreme morphological differences. In *Muricopsis* the shell outline is biconic, the height of the spire equal to, or greater than the length of the canal. The body whorl and the short siphonal canal show little demarcation. In *Murexsul* the two are distinct, with a rounded body whorl and a moderately long, narrow canal. Although the inside of the outer lip in *Murexsul* does bear several denticles, these are very weak in contrast to the extremely large denticles characteristic of *Muricopsis*, which also usually bears a few denticles on the anterior portion of the inner lip as well, not seen in *Murexsul*.

Muricopsis praepauxillus Maury, 1917, in some ways more nearly resembles *Murexsul* than it does *Muricopsis*. But the high spire and the close similarity of the ornamentation to unequivocal species of *Muricopsis*, such as *Muricopsis oxytata* (Smith, 1938) suggest that *Muricopsis* is more appropriate.

A good case could be made for *Murexsul* being placed as a subgenus of *Muricopsis*, but because of the geologic

history of the two groups, both of which go back to the Eocene as separate recognizable genera, there seems little to be gained by uniting them.

***Murexsul mimicus*, new species**
Plate 8, figure 5

Etymology of name.—*L. mimicus* = imitative (in reference to superficial similarity to *Muricopsis praepauxillus*).

Description.—Shell with seven teleoconch whorls and a protoconch of one-and-one-half smooth, bulbous whorls. Spiral ornamentation beginning with three small cords on earliest post-nuclear whorls, one at the shoulder, one just posterior to the suture, and a third between these. The three continue, with that at the shoulder becoming strongest, and with numerous smaller threads intercalated, up to the body whorl. On body whorl, spiral ornamentation of four orders of magnitude: four major cords, three as above, plus one at base of body whorl; between each pair of major cords, sets of alternating larger and smaller intermediate threads; same pattern continued on siphonal canal. Axial ornamentation on earliest whorls of nine or 10 narrow flange-like varices, decreasing to six on each adult whorl; the later varices consisting of multiple laminae, forming short spines where the four major spiral cords cross, that at the shoulder slightly larger. In addition, surface shagreened by intersection of spiral threads and numerous axial growth lines. Aperture ovate, inner lip smooth, slightly appressed at posterior end, free-standing at anterior end; inner side of outer lip with five or six weak elongate denticles. Siphonal canal moderately long, narrow, slightly recurved at distal end, former terminations of canal forming a slight umbilicus.

Diagnosis.—Moderately small muricid with six ridge-like varices. Labium smooth, labrum weakly denticulate. Siphonal canal moderately long, narrow, recurved dorsally.

Holotype.—USNM 365145.

Type locality.—Locality TU 1215, Gurabo Formation; Río Gurabo, bluffs on both sides from the ford on the Los Quemados-Sabaneta road, upstream to approximately 1 km above the ford, Dominican Republic (= locs. USGS 8539–8543; Maury's Zone D; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5).

Material.—Four specimens from locality TU 1215.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 365145 ¹	20.1	11.5	TU 1215
PRI 33048 ²	18.3	12.1	TU 1215

holotype; ² unfigured paratype

Remarks.—From the Gurabo coral reef at locality TU 1215 the TU collections include four examples of

a species of *Murexsul* that is closely related to *M. thalmanni* (Vokes, 1968), which occurs in the Pliocene Agueguexquite Formation of Mexico. There is also a superficial resemblance to *Muricopsis praepauxillus* (Maury, 1917), with which it occurs. In fact, so successfully does this new species mimic the *Muricopsis* it was not until we collected an example of *M. praepauxillus* as large as *Murexsul mimicus*, n. sp., that I was certain it was not just some very large variety of *M. praepauxillus* but a new species.

Comparisons.—From the closely related *Murexsul thalmanni*, the new species *M. mimicus* differs in having a more inflated body whorl and a larger size. From the more distantly related *Muricopsis praepauxillus*, it differs in being larger (in general, although there is one example of *M. praepauxillus* as large as *M. mimicus*, n. sp.), lower spired, with more inflated whorls, and with denticles on the inner side of the outer lip much weaker.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1215).

Distribution.—Gurabo Formation, Dominican Republic.

Genus FAVARTIA Jousseume, 1880

Favartia Jousseume, 1880, p. 335.

Type species.—*Murex breviculus* Sowerby, 1834, by original designation.

Subgenus FAVARTIA *sensu stricto*

***Favartia* (*Favartia*) *zalaya*, new species**

Plate 8, figure 12

Etymology of name.—From Arroyo Zalaya, the type locality.

Description.—Shell with five post-nuclear whorls and a protoconch of one-and-one-half smooth, bulbous turns. Spiral ornamentation initially of two strong cords, gradually developing a median groove and intercalating a smaller cord between each major pair; adult body whorl with six strong flattened cords, alternating with weaker threads; an additional two strong cords on the siphonal canal. Axial ornamentation on first post-nuclear whorl of 10 small laminae, gradually diminishing in number but increasing in strength; adult body whorl ornamented by six rounded varices. Apertural face of the varices covered by minute laminae, looping outward on the spiral cords, giving a scabrous appearance to the shell. Spire high, approximately 60% of total height; suture undulated by varices but not impressed. Aperture rounded; outer lip bearing several weak, paired, lirations within; inner lip smooth, free-standing in advance of the aperture. Siphonal canal broad, very short, recurved at distal end; umbilicus formed by scale-like terminations of former canals.

Diagnosis.—Very small muricid with inflated whorls, each with six rounded varices. Labium smooth. Siphonal canal short, broad, sharply recurved dorsally.

Holotype.—USNM 323901.

Type locality.—Locality TU 1227A, Gurabo Formation; Arroyo Zalaya, which crosses the road to Jánico from Santiago de los Caballeros, 11 km south of the bridge over the Río Yaque del Norte at Santiago, Dominican Republic (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36). Locality TU 1227A is a thin lens, resulting from a turbidity flow, which is between the old bridge (washed out) and the new bridge.

Material.—Three complete specimens and several fragments, all from locality TU 1227A.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323901 ¹	8.0	4.6	TU 1227A
PRI 33049 ²	8.3	4.5	TU 1227A

¹ holotype; ² unfigured paratype

Remarks.—In the gravity-flow lens at Arroyo Zalaya (loc. TU 1227A; see p. 16), there are rare specimens of a small species of *Favartia* (*Favartia*) that is intermediate in appearance between the Miocene to Recent species *Favartia cellulosa* (Conrad, 1846) and the rarer Recent species *F. minirosea* (Abbott, 1954).

The habitat of *F. minirosea* is deeper than that of the other western Atlantic species of *Favartia*, which are usually intertidal to shallow water (less than 50 m). Radwin and D'Attilio (1976, p. 151) record *F. minirosea* from "moderately deep water (50–100 m)" and in the TU collections there are specimens from 30 to 110 m, with an average depth of 67 m. The paleoecologic implications of this deeper habitat suggest that the turbidity flow at locality TU 1227A probably began in moderately shallow water (as indicated by the abundance of cerithiids), washed downslope past the intermediate depth of *F. zalaya*, n. sp., and finally came to rest in the deep water (over 350 m) of the Gurabo Formation at Arroyo Zalaya.

Comparisons.—*Favartia zalaya*, n. sp., has the same general ornamentation as *F. cellulosa*, although more subdued, but the size and overall shape of *F. minirosea*. From the latter species it may be distinguished by the presence of six relatively strong varices (those of *F. minirosea* are almost vestigial) and the lack of the deeply impressed suture of the Recent form. It is assumed that *F. zalaya* is the ancestor of *F. minirosea* and indicates the correctness of Radwin and D'Attilio's (1976, p. 151) placement of the latter in *Favartia*. The latter species was named *Ocenebra* (*Ocenebrina*) *minirosea* Abbott, 1954 (p. 41) and, although I did not agree with that placement, I had no better suggestion until the discovery of the intermediate form, which clearly demonstrates the development of the un-*Favartia*-like

species *minirosea* from the typical *F. cellulosa*.

Occurrence.—Gurabo Formation: Santiago area (TU 1227A).

Distribution.—Gurabo Formation, Dominican Republic.

Favartia (*Favartia*) species

Plate 8, figure 13

Description.—Shell with four post-nuclear whorls and a protoconch of one-and-one-half rounded whorls. Axial ornamentation beginning with 10 tiny varices that lap well onto the smooth protoconch, continuing with 10 per whorl up to the last whorl seen. Spiral ornamentation beginning with two, then three and, on the last whorl, six heavy, flattened cords. Where the spiral cords cross the varices multiple abapertural loops of shell material give a filigreed appearance. Aperture oval, columellar lip smooth, with a short, broad, open siphonal canal.

Diagnosis.—Very small muricid with 10 rounded varices on juvenile whorls, probably fewer in adult. Entire surface of shell covered with a filigree ornament. Labium smooth. Siphonal canal short, broad, sharply recurved dorsally.

Material.—Two specimens.

Measurements.—USNM 323902; height 6.4 mm, diameter 3.9 mm; locality TU 1230.

Remarks.—In the TU collections from the Cercado Formation at Caimito (loc. TU 1230; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 15) and from the Gurabo turbidity-flow lens at Arroyo Zalaya (loc. TU 1227A; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36), there are two small specimens of *Favartia* that are totally unlike any known today. Because the only specimens are both obviously juveniles, it will not be formally named at this time.

Comparisons.—The only species with which this unnamed form may be compared is the common Atlantic species *Favartia cellulosa* (Conrad, 1846), which has fewer spiral cords (five) and fewer varices (about seven) than does this species. The other species of *Favartia* in the Dominican Republic, *F. zalaya*, n. sp., has a much higher spire and only six varices in the adult. As the number of varices in the adult of the unnamed species is unknown, this may not be a useful distinction; but the filigree surface ornament of the unnamed form is distinctive.

Occurrence.—Cercado/Gurabo formations: Río Cana (TU 1230); Santiago area (TU 1227A).

Distribution.—Cercado and Gurabo formations, Dominican Republic.

Subgenus **PYGMAEPTERYS** Vokes, 1978

Pygmaepterys Vokes, 1978, p. 398.

Type species.—*Murex alfredensis* Bartsch, 1915, by original designation.

Favartia (?Pygmaepterys) germainae

(Vokes and D'Attilio)

Plate 8, figure 6

?*Pygmaepterys germainae* Vokes and D'Attilio, 1980, p. 50, pl. 1, figs. 1-4.

Description.—

Shell small, with four post-nuclear whorls and a protoconch of approximately one-and-one-half bulbous whorls, the exact termination being difficult to ascertain among the overlapping varices from the first post-nuclear whorl well onto the protoconch. Spiral ornamentation of two strong cords on the spire; five major spiral cords on the body whorl; three somewhat weaker cords on the siphonal canal. Axial ornamentation of seven varices on each whorl except the last, where there is a tendency to drop one of the varices, leaving a small intervarical node in place of the varix. Intervarical areas covered with elaborately crenulated axial growth lamellae, between and crossing the spiral cords. Each varix forming as a flange, well behind the aperture, with the adaperatural face also ornamented by growth lamellae, with small recurved spinelets where the spiral cords cross the varices, that at the shoulder being the longest; a strong adaperatural flexure at the adapical end of each varix, reflecting the posterior expansion of the inner lip. Aperture oval, inner lip in adult specimens with about four denticles at the anterior end and another two at the expanded and appressed posterior end. Outer lip with six strong denticles, corresponding to the area between the spiral cords. Siphonal canal short, broad, recurved at the distal end, terminations of former canals forming a small fasciole. Shell color a light beige, aperture a rich mahogany. Operculum straw-colored, typically muricoid, with a terminal nucleus. Radula muricopsine. (Vokes and D'Attilio, 1980, p. 50)

Diagnosis.—Small muricid with seven varices on each whorl except the last, which has one less; these formed by a small crenulated flange. Labium with four denticles at anterior end and two denticles at posterior end. Siphonal canal short, broad, recurved dorsally.

Holotype.—USNM 783319.

Type locality.—Recent; off Punta Higüero, north-western Puerto Rico.

Material.—Twenty-five specimens, all from the shallow-water facies of the Gurabo Formation and the Cercado Formation.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 783319 ¹	7.3	4.0	(see above)
USNM 294292 ²	6.8	3.8	TU 1215
PRI 33050	8.3	4.3	TU 1215

holotype; ² paratype

Remarks.—?Pygmaepterys *germainae* Vokes and D'Attilio, 1980, was described from the Recent and fossil fauna of the Caribbean. Morphologically there is a strong resemblance to the East African type species of the genus *Pygmaepterys*, but the radula of *F. germainae* is muricopsine. The question thus becomes: is

F. germainae truly referable to *Pygmaepterys*, which in turn must be then referred to the subfamily Muricopsinae, or is the resemblance just another case of convergence between the species of the muricine subgenus *Pygmaepterys* and the muricopsine species *germainae*? I have no more data than I did in 1980, and so for the time I will assign *germainae* to *Favartia* (?*Pygmaepterys*).

Living examples of this small (less than 9 mm) form have been taken in depths ranging from 12 to 90 m. It is never common, but rare examples have been taken in the Dominican Republic in the Cercado Formation (loc. TU 1230; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 15) and in the more shallow-water facies of the Gurabo Formation (loc. TU 1215; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5), especially at the Arroyo Zalaya turbidity flow (loc. TU 1227A; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36) where there are 16 examples, mostly juveniles.

Comparisons.—The fossil and Recent species *Favartia* (?*Pygmaepterys*) *germainae* is most closely related to the early Miocene *Favartia* (?*Pygmaepterys*) *drezi* (Vokes and D'Attilio, 1980) from the Chipola Formation of northwestern Florida. The younger *F. germainae* differs in being smaller (the older *F. drezi* is approximately twice the size), and with one less varix on the body whorl. The Indo-Pacific species *Favartia* (*Pygmaepterys*) *funafutiensis* (Hedley, 1899) is also close to this species, but the shell is less elaborately ornamented spirally and more ornamented axially. All of these similar-appearing forms have been figured by Vokes and D'Attilio (1980) in their study of the group.

Occurrence.—Cercado/Gurabo formations: Río Cana (TU 1230; NMB 16865); Río Gurabo (TU 1215; NMB 15838); Santiago area (TU 1227A, 1250, 1453A).

Distribution.—Cercado and Gurabo formations, Dominican Republic. Moín Formation, Costa Rica; Pleistocene. Caribbean Sea from Puerto Rico to Panama; Recent.

Genus ACANTHOTROPHON

Hertlein and Strong, 1951

Acanthotrophon Hertlein and Strong, 1951, p. 86.

Type species.—*Trophon* (*Acanthotrophon*) *sorenseni* Hertlein and Strong, 1951, by original designation.

***Acanthotrophon striatus* (Gabb)**

Plate 6, figures 6-8

Muricidea striata Gabb, 1873, p. 203; Pilsbry, 1922, p. 354, pl. 28, fig. 7 (holotype).

Attiliosa striata (Gabb). Vokes, 1976b, p. 111 (in part, Dominican Republic references only), pl. 7, fig. 1 only; text-fig. 2 (holotype).

Acanthotrophon striatus (Gabb). Radwin and D'Attilio, 1978, p. 132 (in part, not figs. 1, 1a, 2); Vokes, 1980a, p. 10, figs. 1 (holotype), 2.

Description.—

Spire elevated about equal to the aperture; whorls eight, including the nucleus; angulated. Body whorl sloping nearly straight above, convex below, the angle constricted in advance. Surface ornamented by seven large ribs on the widest part of the whorls, which become obsolete above and below. Crossing these below the angle are half a dozen linear ribs with broad smooth interspaces. These latter ribs are well developed where they cross the others, but are much smaller in the concave spaces. Mouth subovate, constricted in advance. Incrustation of the inner lip heavy, smooth, and with a projecting free edge; outer lip faintly striate internally. Canal twisted, with a broad imperforate umbilicus. (Gabb, 1873, p. 203)

Diagnosis.—Small muricid with seven varices, visible primarily at the shoulder where a large open spine is produced. Labium smooth, occasionally one small denticle at anterior end. Siphonal canal short, broad, recurved dorsally.

Holotype.—ANSP 3249.

Type locality.—Locality TU 1227A (here restricted), Gurabo Formation; Arroyo Zalaya, which crosses the road to Jánico from Santiago de los Caballeros, 11 km south of the bridge over the Río Yaque del Norte at Santiago, Dominican Republic (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36). Locality TU 1227A is a thin lens, resulting from a turbidity flow, which is located on the north side of the arroyo between the old bridge (washed out) and the new bridge.

Material.—A total of 40 specimens, half of these from locality TU 1227A.

Measurements (in mm).—

specimen	height	diameter	locality
ANSP 3249 ¹	12.3	7.0	unknown
USNM 298655	4.1	2.7	TU 1227A
USNM 323898	14.2	12.5 ²	TU 1215
PRI 33051	14.7	9.3	TU 1227A

¹ holotype; ² including spines

Remarks.—Although originally assigned by Gabb to the genus *Muricidea* Swainson, 1840, a name used for all small muricids of undeterminable placement, I (Vokes, 1976b, p. 111) referred the species to *Attiliosa* Emerson, 1968. Subsequently, Radwin and D'Attilio (1978) showed that *Attiliosa striata* and its kin should be placed in the genus *Acanthotrophon*, and that this genus should be transferred from the Muricinae to the Muricopsinae. It is hoped that this will be the final move for the species.

Acanthotrophon striatus is never common anywhere in the Gurabo Formation, with the exception of the turbidity flow at Arroyo Zalaya (loc. TU 1227A), discussed on p. 16; from this lens there are 23 specimens in the TU collections. Inasmuch as this was almost certainly one of Gabb's localities [see discussion under *Chicoreus* (*Siratus*) *yaquensis*, p. 50] and as the turbidity lens is less than 10 m upstream from the old ford, it seems probable that this is the original location

for Gabb's specimen. Therefore, the type locality is here restricted to locality TU 1227A.

Comparisons.—When I first treated as *Attiliosa* the species *striata* there was but the single type specimen known. Since then we have collected numerous examples, which change previous conclusions. On the basis of the single specimen I felt that the Dominican shell was the same as the numerous examples of a similar species found in western Atlantic beds from mid-Pliocene to mid-Pleistocene age, and also in the Recent fauna of the Florida area, since named *Acanthotrophon striatoides* (Vokes, 1980a, p. 13). However, with additional specimens of *Acanthotrophon striatus* it is obvious that the two are distinct. The Dominican *A. striatus* is always small (our largest examples are ca. 15 mm in height) and it is more inflated than juveniles of the same size in *A. striatoides*. The siphonal canal is shorter and more recurved distally. But most importantly the protoconchs are markedly different (compare Pl. 6, fig. 6, and Vokes, 1980a, fig. 8). The Dominican species is much more variable than formerly realized, as is characteristic of the genus *Acanthotrophon*. The two large examples figured here (Pl. 6, figs. 7, 8 [holotype]) demonstrate the extremes of variation present.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1210, 1211, 1215, 1296; NMB 15804, 15805); Río Mao (TU 1292); Río Amina (TU 1219); Santiago area (TU 1227A, 1453A).

Distribution.—Gurabo Formation, Dominican Republic.

Subfamily **TYPHINAE** Cossmann, 1903

Genus **TYPHIS** Montfort, 1810

Typhis Montfort, 1810, pp. 614–615.

Type species.—*Typhis tubifer* (Bruguière, 1792b), by original designation.

Remarks.—In Opinion 866 (ICZN, 1969) the *International Commission on Zoological Nomenclature* ruled that all designations of type species for the genus *Purpura* Bruguière, 1789, were to be set aside and *Buccinum persicum* Linné, 1758, was to be designated as type species of the genus. This action eliminated the naming of *Purpura tubifer* Bruguière, 1792b, as subsequent monotype and removed the possibility that the genus usually known as *Typhis* Montfort, 1810, could be changed to *Purpura*, with all the confusion that would engender.

D'Attilio (1982) has presented a convincing array of evidence showing that the so-called subfamily Typhinae is actually a massive case of convergence, resulting from a variety of different muricine lineages developing anal siphons or tubes. In particular, he cites *Pterotyphis* Jousseaume, 1880, and *Tripterotyphis* Pils-

bry and Lowe, 1932, as being more allied to the muricine genus *Pterynotus* Swainson, 1833, than to the other members of the Typhinae. There is much value in what he says and in time the subfamily may be totally dismantled. But for the purposes of this study the subfamily will be treated in the traditional fashion.

Subgenus *TYPHINELLUS* Jousseaume, 1880

Typhinellus Jousseaume, 1880, p. 335.

Type species.—*Typhis sowerbii* [sic] Broderip [= *T. sowerbii* Broderip, 1833], by original designation.

Typhis (Typhinellus) sowerbii Broderip

Plate 10, figures 6–8

Typhis sowerbii Broderip, 1833, p. 178; Sowerby, 1841a, pl. 200, figs. 7, 8.

Murex tetrapterus Bronn, 1838, p. 1077, pl. 41, fig. 13a, b.

Murex syphonellus Bonelli in Bellardi and Michelotti, 1841, p. 129, pl. 3, figs. 3, 4.

Typhis sowerbii var. Sowerby, 1841a, pl. 200, fig. 9.

Typhis sowerbii Broderip. Adams and Adams, 1853, p. 76, pl. 8, figs. 2 (animal), 2a, 2b (operculum), 2c (shell).

Typhis (Typhinellus) cf. *quadratus* Hinds. Jung, 1969, p. 493, pl. 50, figs. 5, 6.

Typhis (Typhinellus) sowerbii Broderip. Gertman, 1969, p. 155, pl. 1, fig. 5.

Typhinellus sowerbii (Broderip). Radwin and D'Attilio, 1976, p. 210, pl. 31, fig. 7, text-fig. 154 (radula).

Typhis testa subovata, albida, quadri-vel quinque-fariam varicosa, varicibus laminatis subfrondentibus; tubulus subrectis; canali brevi, subrecurva, gracili. (Broderip, 1833, p. 178)

Description.—

Shell medium-sized, elongate; protoconch smooth, rounded, of one and one-half whorls; five post-nuclear whorls; four smooth to weakly crenulated, convex varices per whorl; a spine at the top of each varix, pointing apically; outer lip of two parts: a weakly ribbed inner band of even width, and an outer flange, greatly flaring anteriorly and weakly crenulated; interapertural area smooth, divided only by the remnant of the outer lip flange at the edge of the varix; tubes closer to preceding than succeeding varices, pointing apically, abaxially, and abaperturally; aperture ovate, surrounded by a raised rim; partition above aperture narrower than outer lip, crossing the shoulder and joining the varix to the varix of the preceding whorl; shoulder depressed; suture distinct; anterior canal closed, narrow, curving sharply to the right and abaperturally. (Gertman, 1969, p. 155)

Diagnosis.—Typhine with four winged varices per whorl, these greatly expanded along siphonal canal; anal tube in each intervarical area. Shell surface unornamented. Aperture entire, smooth. Siphonal canal long, straight; sealed over.

Holotype.—Not found.

Type locality.—Recent; Mediterranean Sea.

Material.—A total of 18 specimens, all from the shallow-water facies of the Gurabo Formation or the Cercado Formation.

Measurements (in mm, unless otherwise indicated).—

specimen	height	diameter	locality
Holotype ¹	7/8 in ²	1/2 in ²	(see above)
USNM 323914	31.8	16.0	TU 1230
USNM 323915	10.7	5.8	TU 1227A
USNM 323916	24.5	14.6	TU 1359
PRI 33052	21.4	10.6	TU 1422

¹ not found; ² *fide* Broderip, 1833

Remarks.—Jung (1969, p. 493, pl. 50, figs. 5, 6) has reported this species from the Matura shell bed of the Talparo Formation, Trinidad, as *Typhis (Typhinellus)* cf. *quadratus*. At the time of Jung's paper *Typhis (Typhinellus) sowerbii* had not been reported outside the Mediterranean Sea. Since Gertman (1969, p. 156) reported the species in the western Atlantic there have been several references to its occurrence, and in the TU collections we now have a large specimen from the Pliocene Agueguexquite Formation of Veracruz, Mexico (loc. TU 638), and several examples from the Dominican Republic.

Jung suggested that a worn specimen from the late Miocene Melajo Clay member of the Springvale Formation might also be referable to the same species as that at Matura. In view of its presence in the Dominican Republic fauna, this is a reasonable assumption. Likewise, he suggested that the references to *Typhis alatus* Sowerby, 1850, from Trinidad by Guppy (1867, p. 157; 1874, p. 438) may also refer to this species, but I have no way of being certain.

This is evidently a shallow-water species as all of the Dominican specimens come from either the Cercado Formation or from the shallow-water turbidity flow in the Gurabo Formation (loc. TU 1227A; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36); from the latter 11 examples have been taken. The depth range of living specimens of *T. sowerbii* in the western Atlantic is from 50 to 110 m (Gertman, 1969, p. 156), but in the Mediterranean the species is common from 10 to 40 m in a wide variety of habitats, ranging from grass flats to coralline detritus (Franchini, 1973, pp. 132–133).

Comparisons.—As presently understood the subgenus *Typhis (Typhinellus)* is monotypic; therefore, there is no species with which it may be compared. The nearest allied species are those of the subgenus *Typhis* *alatus* Jousseaume, 1880 (type species: *Typhis grandis* Adams, 1855a). In those species the varical wing is also expanded along the siphonal canal but the face is elaborately fimbriated, in contrast to the smooth plate-like flange of *T. sowerbii*.

Whether this degree of difference is of subgeneric level is largely philosophical; the radulae, as figured by Radwin and D'Attilio (1976, text-figs. 154 [*T. sowerbii*]

and 155 [*T. grandis*]), are not significantly different.

Occurrence.—Cercado/Gurabo formations: Río Cana area (TU 1230, 1422; NMB 16839); Río Gurabo (TU 1359; NMB 15838); Río Mao (TU 1410); Santiago area (TU 1227A).

Distribution.—Cercado and Gurabo formations, Dominican Republic. Agueguexquite Formation, Mexico; Matura shell bed of Talparo Formation, Trinidad; Astian Stage, Italy; Pliocene. Mediterranean Sea, Gulf of Mexico and Caribbean Sea; Recent.

Subgenus *TALITYPHIS* Jousseaume, 1882

Talityphis Jousseaume, 1882, p. 338.

Type species.—*Typhis expansus* Sowerby, 1874a, by original designation.

Typhis (Talityphis) obesus Gabb

Plate 10, figure 1

Typhis obesus Gabb, 1873, p. 203; Guppy and Dall, 1896, p. 313 (in part, not reference to Jamaican specimens); Pilsbry, 1922, p. 354, pl. 28, figs. 5, 6 (holotype); Ramirez, 1956, p. 10; Vokes, 1979, p. 112.

Typhis alatus obesus Gabb, Dall, 1890, p. 151.

Typhis alatus Sowerby, Brown and Pilsbry, 1911, p. 354 (not of Sowerby, 1850).

Typhis sp. cf. *T. alatus* Sowerby, Woodring, Brown, and Burbank, 1924, p. 183 (in part, loc. USGS 9907 only).

Not *Typhis alatus obesus* Gabb, Maury, 1925b, p. 336, pl. 36, figs. 6, 9 [= *Typhis (Talityphis) precursor* Keen and Campbell, 1964].

Not *Typhis (Talityphis) alatus obesus* Gabb, Woodring, 1928, p. 294, pl. 18, figs. 3, 4; Keen, 1943, pp. 33, 53, pl. 3, figs. 13, 18, 22 [= *Typhis (Talityphis) expansus* Sowerby, 1874a].

Typhis (Talityphis) alatus obesus Gabb, Gardner, 1947, p. 527, pl. 53, figs. 15, 16; Woodring, 1959, p. 221, pl. 31, figs. 3, 4.

Typhis (Talityphis) obesus Gabb, Gertman, 1969, p. 160, pl. 4, figs. 1–4; Vokes, 1983, p. 125, pl. 1, fig. 4.

Shell short, broad; spire very low; whorls eight, sharply angulated; concave above the surface, sloping convexly below; varices four to each whorl, acute-angular on their margins, and ending in a blunt process on the upper angle of the whorl; tubes moderate, pointed laterally, below each tube the surface of the shell is greatly swollen, and two lines pass anteriorly, one being the margin of the old mouth, the other, in advance of the tube, being similar in character and indicating another arrest in growth. Surface polished, marked by faint lines of growth, and crossed below the angle by a few irregular transverse lines, not ribs. Aperture small, oval, bordered by a prominent, acute raised margin; canal closed, short, recurved; front face of terminal varix marked by five small ribs radiating from the outer lip. (Gabb, 1873, p. 203)

Description.—

Shell large, stout; [protoconch smooth, rounded, of one-and-one-half whorls]; six post-nuclear whorls; four convex varices per whorl, crossed by five weak ribs; outer lip of constant width, greatly expanded, consisting of an inner band, and an outer flange; aperture large, ovate, surrounded by a raised rim; tubes closer to preceding than succeeding varices; pointing abaxially, apically, and abaperturally; a partition above the aperture crossing the shoulder and joining the varix to the varix of the preceding whorl; shoulder slightly concave, crossed by remnants of the partitions; suture distinct; in-

terapertural area of three parts: the area under the tube; the wide flange of the new varix, formed with five ribs and a short blunt spine at the apical end; and, the inner band formed within the flange of the varix and crossed by five ribs; anterior canal closed, short, and broad, pointing to the right and abaperturally. (Gertman, 1969, p. 162)

Diagnosis.—Typhine with four winged varices per whorl, these not expanded along siphonal canal; anal tube in each intervarical area. Shell surface unornamented. Aperture entire, smooth. Siphonal canal short, broad; sealed over.

Holotype.—ANSP 3251.

Type locality.—Locality TU 1226 (here restricted), Baitoa Formation; east side of the Río Yaque del Norte, below the village of Baitoa, and above the confluence of the Río Yaque and the Río Bao, Dominican Republic (= loc. USGS 8558; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 21).

Material.—Four specimens, all from the Baitoa Formation.

Measurements (in mm).—

specimen	height	diameter	locality
ANSP 3251*	24.8	18.4	unknown
PRI 33053	23.3	17.4	TU 1226

* holotype

Remarks.—As I have indicated in an earlier paper (Vokes, 1979, p. 112), in the Dominican Republic this species is confined to the Baitoa Formation. All examples have come from near Baitoa and, therefore, the type locality is restricted to locality TU 1226.

However, the species is not confined to the Baitoa Formation, for in other areas it is common and widespread, especially in the Chipola Formation of Florida, where it occurs at almost every locality. In the material collected by the U. S. Geological Survey in the Thomonde Formation of southern Haiti (loc. USGS 9907; see Woodring, Brown, and Burbank, 1924, p. 177) there are numerous juvenile examples (USNM 481722). It has also been found in the Pliocene Gatun Formation of Panama but it has not been taken in the shallow-water Cercado Formation or in the more shallow-water facies of the Gurabo Formation. In the Mao Formation, which is correlated with the Gatun Formation, we find instead *Typhis (Talityphis) expansus* Sowerby, 1874a.

Comparisons.—All of the species of *Typhis (Talityphis)* are much alike, and in the Dominican Republic there are representatives of three of these species; however, none occur together stratigraphically. In the stratigraphically oldest Baitoa Formation there is the low-spined, well-named “obese”, *T. obesus*; in the Gurabo Formation, there is the high-spined, slim, *T. alatus* Sowerby, 1850; in the stratigraphically youngest Mao Formation, the species is the tall, slim *T. expansus*

Sowerby, 1874a. The latter is similar to *T. obesus* in that both are smooth in the intervarical area, in contrast to the strong intervarical node present in *T. alatus*. These distributions are not due to a change through time in the lineage but are apparently controlled by environment. The shallow-water species *T. obesus* also occurs in the Pliocene Gatun Formation of Panama, and there is a single example of *T. alatus* also reported from the deeper-water, more offshore portions of the Gatun (Vokes, 1983, p. 124).

Occurrence.—Baitoa Formation: Baitoa area (TU 1226, 1364).

Distribution.—Baitoa Formation, Dominican Republic. Thomonde Formation, Haiti; Chipola Formation, Florida; early Miocene. Gatun Formation, Panama; Pliocene.

***Typhis (Talityphis) alatus* Sowerby**
Plate 10, figures 2–5; Text-figure 20

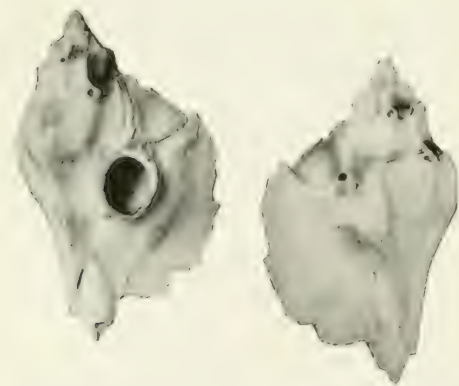
Typhis alatus Sowerby, 1850, p. 48, pl. 10, fig. 4; Guppy, 1876, p. 522 (in part only); Brown and Pilsbry, 1911, p. 354; Maury, 1917, p. 100(264); Vaughan and Woodring in Vaughan *et al.*, 1921, p. 141; Pilsbry, 1922, p. 354.

Not *Typhis alatus* Sowerby. Olsson, 1922, p. 132, pl. 10, fig. 15 [= *Typhis (Talityphis) expansus* Sowerby, 1874a]; Bullis, 1964, p. 107 [= *T. expansus* Sowerby, 1874a].

Typhis (Talityphis) alatus Sowerby. Olsson, 1964, p. 141; Gertman, 1969, p. 159, text-fig. 3 (holotype); Vokes, 1983, p. 124, pl. 1, figs. 1–3; Vokes, 1988, p. 46, pl. 6, figs. 3, 4.

Testa ovato-oblonga, subfusiformis, transversim striata, anfractibus senis, quadrifariam varicosis, costellis brevibus intermediis; varice ultimo lato, tenui, radiatim striato, canali longiusculo, obiecto.

Distinguished by the tenuity and great extent of the wing-like varix from all known species. (Sowerby, 1850, p. 48)



Text-figure 20.—Apertural and abapertural views of *Typhis (Talityphis) alatus* (Sowerby). Holotype, BMNH GG. 20084, $\times 2$. Height 29.5 mm, diameter 18.0 mm. (Photo courtesy of BMNH)

Description.—

Shell elongate; [protoconch smooth, rounded, of one-and-one-half whorls;] five post-nuclear whorls; four straight varices per whorl; outer lip of two parts: an inner band and a wide, thin, outer flange; a moderately long, recurved spine at shoulder of apertural varix, surrounded by outer lip; large partition, joining the varix to the varix of the preceding whorl; shell surface almost completely smooth, four very faint spiral lines, visible only on apertural face of varices; aperture small, circular, surrounded by a raised rim; tubes closer to the preceding than succeeding varices, pointing abaxially and abaperturally; shoulder depressed; anterior canal closed, narrow, straight. (Gertman, 1969, p. 159)

Diagnosis.—Typhine with four winged varices per whorl, these not expanded along the siphonal canal; anal tube in each intervarical area and anterior to the tube a narrow ridge. Shell surface unornamented. Aperture entire, smooth. Siphonal canal moderately long, broad, straight; sealed over.

Holotype.—BMNH GG. 20084.

Type locality.—Locality TU 1448 (here restricted)⁷, Gurabo Formation; Río Yaque del Norte, west side, bluffs extending for approximately 1 km upstream from the village of La Barranca.

Material.—Twenty specimens, all but one from the Gurabo Formation.

Measurements (in mm).—

specimen	height	diameter	locality
BMNH GG. 22084*	29.5	18.0	unknown
USNM 323911	40.4	22.7	TU 1249
USNM 323910	27.7	17.3	TU 1212
USNM 323912	11.5	6.7	TU 1250
USNM 323913	23.5	14.6	TU 1250
PRI 33054	24.0	15.3	TU 1353

* holotype

Remarks.—When Gertman (1969, p. 159) monographed the western Atlantic species of the Typhinae he noted that *Typhis (Talityphis) alatus*, originally described without a locality except “Santo Domingo”, was still as much a mystery as when first found. Only two specimens were known: the type, now in the BMNH; and a juvenile in the Gabb Collection at the ANSP. Our collecting has produced 20 adult specimens of this rare species and now it is possible to state that it occurs primarily in the Gurabo Formation, but a single huge example (Pl. 9, fig. 2) has been collected in the older unnamed beds of the Gurabo facies west of San Cristobal (loc. TU 1249 — see *Remarks* under *Homalocantha* sp. [p. 66]).

In addition, Olsson (1964, p. 141) reported the occurrence of a single small specimen from the Pliocene Picaderos Formation of northwestern Ecuador. This shell (USNM 645453), although smaller than normal (about one-half the size of the usual Dominican Re-

⁷ Gertman (1969, p. 160) indicated “Río Yaque, Dominican Republic”, as type locality. The restriction is made more specific here.

public examples) and in somewhat poor condition, seems to be an unquestionable specimen of *T. alatus*. The species has been reported (Vokes, 1988, p. 46) from the Esmeraldas beds at Río Camarones and the Angostura Formation at Punta Verde, in northwestern Ecuador. Vokes (1983, p. 124) also reported the first record of *T. alatus* in the Gatun Formation of Panama. However, it is rare in Panama and the more common species of *Talityphis* is *T. obesus* Gabb, 1873.

Comparisons.—The name *Typhis alatus* Sowerby, 1850, has been applied to the living *Typhis* (*Talityphis*) *expansus* Sowerby, 1874a. The Gurabo Formation specimens of *Typhis* (*Talityphis*) *alatus* were compared with our numerous examples of *T. expansus* from the Pleistocene Moín Formation of Costa Rica (locs. TU 953, 954, 956, 1239, 1240, 1307 — over 40 in all), as well as Recent Caribbean examples, and it can be seen that there is always one consistent difference between the two. In *T. alatus* there is a marked swelling anterior to the tubes, forming an "intervalar node" (see Pl. 10, fig. 3b). This is never present in *T. expansus* or *Typhis* (*Talityphis*) *obesus* but it is seen in the Gatun Formation species *Typhis* (*Talityphis*) *eucteanus* Woodring, 1970 [= *Typhis* (*Talityphis*) sp. of Gertman, 1969, p. 160, pl. 5, fig. 1], which Gertman noted was most like *T. alatus*. However, the latter is even taller and more elongate than *T. alatus*. The tall, noded *T. alatus*, other than its Panama Pliocene relative *T. eucteanus*, seems to have left no descendants.

Occurrence.—Unnamed formation: San Cristobal area (south coast) (TU 1249). Gurabo Formation: Río Gurabo (TU 1211, 1212, 1231); Santiago area (TU 1227, 1250, 1353, 1381, 1404, 1448, 1449, 1453; NMB 17267).

Distribution.—Unnamed beds west of San Cristobal and Gurabo Formation; Dominican Republic. Picaderos, Esmeraldas, and Angostura formations, Ecuador; Gatun Formation, Panama; Pliocene.

Typhis (*Talityphis*) *expansus* Sowerby

Plate 10, figure 9; Text-figure 21

Typhis expansus Sowerby, 1874a, p. 719, pl. 59, fig. 4; Sowerby, 1874b, pl. 3, fig. 12; Sowerby, 1880, pl. 284b, figs. 24, 25.

Typhis alatus Sowerby, Olsson, 1922, p. 132, pl. 10, fig. 15; Bullis, 1964, p. 107 (not of Sowerby, 1850).

Typhis (*Talityphis*) *alatus obesus* Gabb. Woodring, 1928, p. 294, pl. 18, figs. 3, 4; Keen, 1943, pp. 33, 53, pl. 3, figs. 13, 18, 22 (not of Gabb, 1873).

Typhis (*Talityphis*) *expansus* Sowerby. Keen, 1943, p. 53, pl. 3, fig. 20; Gertman, 1969, p. 167, pl. 5, fig. 5; Bayer, 1971, p. 166, figs. 35B, 36A, 37A-C.

Typhis (*Talityphis*) *obesus* Gabb. Gertman, 1969, p. 160 (in part, not of Gabb, 1873), pl. 4, fig. 3 only.

Not *Talityphis expansus* (Sowerby). Radwin and D'Attilio, 1976, p. 201, pl. 31, fig. 3 [= *Typhis* (*Rugotyphis*) *puertoricensis* Warmke, 1964].

Talityphis perchardei Radwin and D'Attilio, 1976, p. 236, pl. 30, fig. 15, text-figs. 190 (shell), 191 (protoconch), 192 (radula).

T. testa subfusiformi, albida, pallide fusco tincta; spira breviuscula, acuminato-turrita; anfractibus transversim obscure liratis, superne angulatis, supra angulum concavis, quadrivericosis; varicibus tenuibus, ad angulum falcatis, varice ultimo late expanso reflexo; tubis inter varices brevibus, ultima elongata; canali breviusculo; apertura ovali. (Sowerby, 1874a, p. 719)

Description.—

Shell large, stout; protoconch of one and one-half smooth, bulbous whorls; five post-nuclear whorls; four convex varices crossed by four weak ribs; outer lip wide, of two parts: an inner band and an outer flange that curls abaperturally; a spine at the top of the apical end of the varix; a partition above the aperture crossing the shoulder and joining the varix to the varix of the preceding whorl; interapertural area smooth under the tubes and ribbed on the varices; aperture ovate, surrounded by a raised rim; tubes closer to preceding than succeeding varices, pointing abaxially, abaperturally, and apically; shoulder depressed slightly; anterior canal closed, narrow, curving abaperturally and to the right. (Gertman, 1969, p. 167)

Diagnosis.—Typhine with four winged varices per whorl, these greatly drawn out into a triangular projection at the shoulder, not expanded along the siphonal canal; anal tube in each intervalar area. Shell surface unornamented. Aperture entire, smooth. Siphonal canal long, broad, straight; sealed over.

Holotype.—National Museum of Wales, No. 1955.158.19.

Type locality.—Recent; Paramaribo, Surinam (Dutch Guiana) (restricted by Gertman, 1969, p. 167).

Material.—Ten specimens, all from the upper Mao Formation.

Measurements (in mm).—

specimen	height	diameter	locality
National Museum of Wales, No. 1955.158.19 ¹	22.5 ²	13.4 ²	(see above)
NMB H 16998	29.7	21.7	NMB 15833
PRI 33055	27.0	21.7	TU 1352

¹ holotype; ² *vide* Oliver, written commun., 1981

Remarks.—From the upper member of the Mao Formation, near Gurabo Afuero, along the lower part of the Río Gurabo, the TU and NMB teams combined have collected 10 specimens of *Typhis* (*Talityphis*) *expansus*. This species is abundant in the Pleistocene Moín Formation of Costa Rica, in beds that are thought to have been deposited in approximately 50 m of water, and Bayer (1971, p. 167) cites numerous stations in the southern Caribbean with depths ranging from 18 to 73 m, averaging 50.4 m. Radwin and D'Attilio (1976, p. 238) note that living examples occur in depths of 35 to 60 m, on a fine silt or clay bottom. This is much too shallow for the Mao Formation and the presence of this species is the result of a gravity flow into the blue clays of that very deep-water formation. At the same locality other relatively shallow forms are also to be encountered [see *Murex* (*Haustellum*) *messorius*

Sowerby, 1841a, and *Chicoreus* (*Phyllonotus*) *pomum* (Gmelin, 1791), pp. 25 and 40, respectively].

Because of the overall similarity of all of the members of *Talityphis*, the nomenclature of this species has been more than usually complicated by misidentifications. It has been variously referred to *Typhis* (*Talityphis*) *alatus* Sowerby, 1850 [see p. 76], *T. obesus* Gabb, 1873, and *T. expansus*. More recently, it was stated by Radwin and D'Attilio (1976, p. 201) that *T. expansus* is a synonym of the subsequently named *Typhis puertoricensis* Warmke, 1964, which would leave the Caribbean species usually cited as *T. expansus* without a name. Therefore, they proposed for it *Typhis perchardei* (Radwin and D'Attilio, 1976, p. 236), although nowhere do they note that the name *T. perchardei* is for the *T. expansus* of authors.

If *Typhis puertoricensis* were the *T. expansus* of authors then a serious problem would arise, as *T. expansus* is the type species of the subgenus *Talityphis* Jousseaume and *T. puertoricensis* is better assigned to the subgenus *Rugotyphis* Vella, 1961. However, we are spared this complication as the holotype of Sowerby's species is in the collections of the National Museum of Wales at Cardiff. Photographs of the specimen (Text-fig. 21) kindly provided by Dr. P. Graham Oliver, show

that *T. expansus* is the species so identified by most workers.

Comparisons.—Although Gertman (1969, pl. 4, fig. 3) considered the Bowden Formation examples of *Talityphis* as being nearer to *T. obesus* than to the Recent species *T. expansus*, much additional material demonstrates that the Bowden specimens are the same as those that occur in the correlative Moín Formation of Costa Rica, as well as in the Recent fauna of the Caribbean. *Typhis expansus* and *T. obesus* are similar, but the differences, although subtle, are constant. *Typhis expansus* has a smaller aperture (at the same size), and the shoulder spine is recurved dorsally, rather than turned adapically as in *T. obesus*. The result of this is that the shell of *T. expansus* has a wider partition and a more triangular appearance, in contrast to the globose appearance of the well-named *T. obesus*.

Occurrence.—Mao Formation: Río Gurabo (TU 1352; NMB 15832, 15833).

Distribution.—Mao Formation, Dominican Republic. Bowden Formation, Jamaica; Moín Formation, Costa Rica; Pleistocene. Caribbean Sea; Recent.

Genus *SIPHONOCHELUS* Jousseaume, 1880

Siphonochelus Jousseaume, 1880, p. 335.

Type species.—*Typhis avenatus* [sic] Hinds [= *T. arcuatus* Hinds, 1843], by original designation.

Remarks.—Between the two subgenera *Siphonochelus* sensu stricto and *Laevityphis* Cossmann, 1903, there is usually a marked distinction, species of the former having the tubes within the varices and of the latter having the tubes completely independent, midway between each pair of varices. However, in the New World, apparently starting with *S. cercadicus* (Maury, 1917), there is a trend toward a small spinelet or "cusp" in advance of the tube. As this cusp becomes larger it tends to break off, leaving what appears to be a small tube in front of the real tube. This trend culminates in two Recent species in the western Atlantic: *S. radwini* Emerson and D'Attilio, 1979, and a second that was misidentified by Bayer (1971, p. 161, figs. 31, 34A, 35A, 36B) as *Typhis longicornis* Dall, 1888, but which has a much stronger cusp and varical flange than Dall's species. Bayer's "*S. longicornis*" subsequently was named *Typhina riosi* by Bertsch and D'Attilio (1980, p. 135, figs. 6, 7) but, in my opinion, the species cannot be assigned to *Typhina* Jousseaume, 1880, which is characterized by having a free-standing flange along the entire varix. *Siphonochelus riosi* would seem to represent parallel development within the genus *Siphonochelus*, resulting in the development of a small free-standing rim of shell material along the varical edge on what is an otherwise typical, smooth, species of *Siphonochelus*. A trend toward this is seen in *S.*



Text-figure 21.—Apertural and abapertural views of *Typhis* (*Talityphis*) *expansus* Sowerby. Holotype, National Museum of Wales, No. 1955.158.19, $\times 3$. Height 22.5 mm, diameter 13.4 mm. (Photo courtesy of National Museum of Wales)

cercadicus, where unworn examples have a small flange along the margin of the cusp.

Siphonochelus cercadicus is much closer to the living *S. longicornis* (Dall, 1888), type species of *Trubatsa* Dall, 1889a, than was previously recognized. Radwin and D'Attilio distinguished *Trubatsa* from the typical *Siphonochelus* on the basis that in *Trubatsa* "the tube is not integrally associated with the varix and does not impart this swept appearance to the upper portion of each whorl" (Radwin and D'Attilio, 1976, p. 204). The actual difference is that in the Old World species of *Siphonochelus*, the suture forming the tube is twisted around to the posterior edge (adapically) of the tube, but in the New World species (those that would be placed in *Trubatsa*), the suture is on the adapertural edge. This gives rise to a more flattened tube in the typical Old World form, but a circular tube in the New World ones. The Australian species *S. pavlova* (Iredale, 1936) superficially resembles the New World species of *Trubatsa* but this is probably parallelism, as Iredale notes (1936, p. 324) "the last tube on the last whorl is produced into a long thin tube, the preceding ones being short and squat and somewhat compressed below into an obscure longitudinal rounded rib." His illustration (Iredale, 1936, pl. 12, fig. 12) certainly shows the flattened tubes of a typical species of *Siphonochelus* except for the extremely long and adapically (not dorsally) extended final tube. The swept-back appearance of the New World species is due to the more anterior location of the suture.

Geologically speaking, *Laevityphis* is the older subgenus, beginning in the Eocene of both the Old and New World. The ancestral line has continued without change to the Recent but in the Oligocene of Germany, *Siphonochelus* sensu stricto seemingly branched off. So far as is known, *S. cercadicus* is the oldest member of the subgenus in the New World and almost certainly represents parallelism between the Old World line and the New, in each of which there was a move to incorporating the tube within the varix.

If one wished, a case might be made for separating the subgenus *Trubatsa* as a New World line, characterized by the presence of the varical cusp. All of the Old World fossil species of *Siphonochelus*, as well as *S. arcuatus* (Hinds, 1843), the Recent type species of the genus, have no such cusp. This New World line begins, so far as is known, with *S. cercadicus*, and then divaricates into two branches, one in which the cusp is strengthened (*S. radwini* Emerson and D'Attilio and *Typhina riosi* Bertsch and D'Attilio) and one in which the cusp is diminished, almost the point of disappearing (*S. longicornis* and *S. tityrus* Bayer, 1971). The problem with separating these as a separate subgenus is caused by the two latter species, which mimic true species of *Siphonochelus* so closely, as well as the Aus-

tralian species *S. pavlova* (Iredale, 1936), which mimics the New World species of *Trubatsa*. With this parallelism it seems more reasonable to consider them all as simply species of *Siphonochelus*. As an example of the sort of confusion engendered, Emerson and D'Attilio (1979, p. 9) suggested that their new species *Siphonochelus radwini* was "the first record of a living representative" of *Siphonochelus* from the New World. Certainly, *S. radwini* should not be separated from *S. longicornis*; either it is a species of *Trubatsa*, or *S. longicornis* is another species of *Siphonochelus*.

Subgenus SIPHONOCHELUS sensu stricto

Siphonochelus (*Siphonochelus*) *cercadicus* (Maury)

Plate 9, figure 7

Typhis cercadicus Maury, 1917, p. 101(265), pl. 16(42), fig. 12; Woodring, 1928, p. 294.

Laevityphis (*Laevityphis*) *cercadicus* (Maury). Keen, 1944, pp. 59, 64.

Siphonochelus (*Siphonochelus*) *cercadicus* (Maury). Gertman, 1969, p. 168, pl. 6, fig. 1 (holotype).

Shell small, each whorl with four varices and four tubes, the tubes arising slightly behind the varices; on the last whorl are faint indications of about six raised spiral lines; the whorls are shouldered and the varices end at the shoulder; canal wide, covered, former position of canal indicated by a tubular process beside the canal. (Maury, 1917, p. 265)

Description.—

Shell small, stout; [protoconch smooth, rounded, of one-and-one-half whorls;] four post-nuclear whorls; four smooth, rounded, convex varices per whorl; outer lip smooth, narrow, and of constant width; interapertural area of only one part; tubes attached to varices, pointing abaxially, apically, and abaperturally; shell smooth; aperture rounded-ovate, surrounded by a raised rim; outer lip narrowing above the aperture; shoulder raised; suture distinct; anterior canal closed, narrow, pointing to right and abaperturally. (Gertman, 1969, p. 170)

Diagnosis.—Small typhine with four rounded varices per whorl; long anal tube in each intervarical area. Shell surface unornamented. Aperture entire, smooth. Siphonal canal very long, narrow, somewhat deflected dorsally; sealed over.

Holotype.—PRI 28756 (formerly Cornell University Paleontological Collections No. 36813).

Type locality.—Gurabo Formation; Río Mao, Bluff 1, Cercado de Mao, Dominican Republic (= loc. TU 1293; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 29).

Material.—Over 100 specimens, the vast majority from locality TU 1227A.

Measurements (in mm).—

specimen	height	diameter	locality
PRI 28756 ¹	6.6	3.9	Bluff 1, Río Mao ²
USNM 323907	10.0	4.6 ³	TU 1227A

¹ holotype; ² of Maury, = loc. TU 1293; ³ excluding spines

Remarks.—*Siphonochelus* (*Siphonochelus*) *cercadicus* (Maury, 1917) was based upon a single tiny specimen from the Gurabo Formation on the Río Mao near Cercado de Mao, hence its inappropriate name, which suggests that it occurs in the Cercado Formation. The holotype is only 6.6 mm in height but this is the typical size. Gertman (1969, p. 170) thought that the holotype was a juvenile but apparently this is as large as the species grows. Our collections contain examples from other localities, especially locality TU 1227A (Arroyo Zalaya; see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36) with more than 100 specimens. The figured specimen is the largest in the TU collections, but most of its height is in the extremely long siphonal canal. Without this canal the shell would be about 7 mm in height.

The species is almost completely confined to the Gurabo Formation, occurring over a wide geographic area. However, a single example was collected by the NMB team in the Mao Formation from the gravity-flow lens at Gurabo Afuero (loc. NMB 15833).

Comparisons.—As noted above, there are four Recent species of *Siphonochelus* sensu stricto in the western Atlantic that all seem to be descended from *S. cercadicus*. In *S. longicornis* and *S. tityrus* the varical cusp is almost non-existent; in *S. riosi* and *S. radwini* this cusp is stronger than in the fossil species. An excellent comparison of the "diminished" cusp vs. the "increased" cusp was given by Bayer (1971, fig. 34), showing, also, the contrast with *Siphonochelus* (*Laevityphis*) *bullisi* Gertman, 1969, in which the tube is completely independent of the varix.

Occurrence.—Gurabo Formation: Río Gurabo (NMB 15805); Santiago area (TU 1227A, 1250, 1381, 1453A); Río Mao area (TU 1225, 1409). Mao Formation: Río Gurabo (NMB 15833).

Distribution.—Gurabo and Mao formations, Dominican Republic.

Subgenus **LAEVITYPHIS** Cossmann, 1903

Laevityphis Cossmann, 1903, p. 59.

Type species.—*Typhis coronarius* Deshayes, 1865 [= *Typhis muticus* Sowerby, 1835], by original designation.

***Siphonochelus* (*Laevityphis*) *apheles*, new species**

Plate 9, figure 8

Typhis sp. cf. *T. alatus* Sowerby. Woodring, Brown, and Burbank, 1924, p. 183 (in part, loc. USGS 9946 only).

Etymology of name.—Gr. *apheles* = smooth, simple.

Description.—Shell stout, with six post-nuclear whorls, protoconch unknown. Four convex varices per whorl; with a small spine at apical end of varix; large partition riding up on preceding whorl to form a strong

buttress-like structure with a deep concavity behind it; suture impressed. Intervarical area in two parts; first, the area anterior to the tube; second, the former varix, the two being separated by a deep line of contact, which is sharply angled at the base of the body whorl. Aperture small, ovate-rounded, with an entire, raised peristome. Tubes midway between varices, pointing abaxially. Anterior canal short, narrow, closed, distally recurved.

Diagnosis.—Typhine with four rounded varices per whorl; each with a small spine at the apical end; anal tube in each intervarical area. Shell surface unornamented. Aperture entire, smooth. Siphonal canal short, narrow, reflected dorsally; sealed over.

Type locality.—Locality TU 1226, Baitoa Formation, east side of Río Yaque del Norte, below the village of Baitoa, and above the confluence of the Río Yaque and the Río Bao, Dominican Republic (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 21).

Material.—The type lot, consisting of two specimens.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323908 ¹	14.5	9.6	TU 1226
USNM 482626 ²	8.6	5.5	USGS 9946 ³

¹ holotype; ² unfigured paratype; ³ see Woodring, Brown, and Burbank, 1924, p. 175

Remarks.—Although *Siphonochelus* (*Laevityphis*) *apheles*, n. sp., is based upon just two worn specimens, one from the Baitoa Formation (holotype) and one from the correlative Thomonde Formation of Haiti (USNM 482626), it is so different from all other species of *Siphonochelus* (*Laevityphis*) that it is here described.

Comparisons.—*Siphonochelus* (*Laevityphis*) *apheles*, n. sp., is most similar in terms of overall shell morphology to a peculiar species from the Gatun Formation, *Siphonochelus* (*Pilsbrytyphis*) *gabbi* (Brown and Pilsbry, 1911). The unmistakable difference between the two lies in the surface ornamentation of *S. gabbi*, which Woodring (1959, p. 220) most aptly termed "peanut-shell" and which caused him to erect the subgenus *Pilsbrytyphis* Woodring, 1959, for this and related species. The sculpture is not due to environment or an artifact of bryozoan-coating, as it may appear, for the TU collections contain other examples of *S. gabbi* from the Río Banano Formation of Costa Rica (loc. TU 967), which have sculpture identical to the type lot.

But other than the smooth surface of the Baitoa shell typical of *Laevityphis* sensu stricto, there is a remarkable similarity in the two, and almost certainly the Baitoa Formation species is ancestral to the strange *Siphonochelus* (*Pilsbrytyphis*) *gabbi*. The two are unique among the species of *Siphonochelus* (*Laevityphis*) in

having an extremely large partition. This large partition is sufficient to separate *S. (L.) apheles* from all other species of *Laevityphis*, except for *Siphonochelus (Laevityphis) sawkinsi* (Mansfield, 1925).

All species of *Siphonochelus (Laevityphis)* are monotonously alike and the specific distinctions are based upon the relative size of the partition and the varical spine. The Trinidadian species *S. sawkinsi* shares with the two above-mentioned species a large partition, but lacks the varical spine and has the tube nearer the varix than in the other species of *Laevityphis*. (Perhaps it represents the intermediate step toward the line of *Siphonochelus* sensu stricto discussed above.)

The species from the early Miocene Cantaure Formation of Venezuela, identified by Jung (1965, p. 525, pl. 70, figs. 7, 8) as *Typhis (Laevityphis) sawkinsi* Mansfield is not that species, but rather a large variant of *Siphonochelus (Laevityphis) linguiferus* (Dall, 1890), from the time-correlative Chipola Formation of Florida, which shares with the Venezuela form distinct upturned spines on the varices. The two are identical except for the larger size of the Venezuelan examples.

Occurrence.—Baitoa Formation: Baitoa area (TU 1226).

Distribution.—Baitoa Formation, Dominican Republic. Thomonde Formation, Haiti; early Miocene.

***Siphonochelus (Laevityphis) spinirectus*, new species**
Plate 9, figure 9

Etymology of name.—*L. spina* = thorn + *L. rectus* = straight.

Description.—Shell with six post-nuclear whorls and a protoconch of one-and-one-half bulbous, glassy whorls. Four simple convex varices per whorl, with a large sharp spine at the shoulder of each varix, directed almost perpendicular to the axis of the shell; ends usually broken away and appearing as small tube-like structures but not connecting to interior of the shell. Intervarical area of two parts, that beneath the tube and part of the previous varix, a sharp line dividing the two, with a marked angulation at the base of the body whorl. Outer lip of a constant width; aperture ovate, with a raised peristome. Tubes midway between the varices, directed perpendicular to the axis of the shell and abaperturally. Surface smooth, with only faint axial growth lines. Suture distinct. Anterior canal closed, narrow and recurved at the distal end.

Diagnosis.—Typhine with four rounded varices per whorl, these having a large spine directed perpendicular to the axis; anal tube in each intervarical area. Shell surface unornamented. Aperture entire, smooth. Siphonal canal moderately long, narrow, recurved dorsally; sealed over.

Holotype.—USNM 323909.

Type locality.—Locality TU 1227, Gurabo Formation; Arroyo Zalaya, which crosses the road to Jánico from Santiago de los Caballeros, 11 km south of the bridge over the Río Yaque del Norte at Santiago, Dominican Republic (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 36).

Material.—Nineteen examples (most from loc. TU 1227) from the deep-water facies of the Gurabo Formation.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323909 ¹	12.6	7.6	TU 1227
PRI 33056 ²	15.1	9.8	TU 1250

¹ holotype; ² unfigured paratype

Remarks.—Only at the type locality, Arroyo Zalaya, is *Siphonochelus (Laevityphis) spinirectus*, n. sp., found in any numbers. From here there are ten examples; all other localities have yielded but a single specimen each. From this it is assumed that *S. spinirectus* lived in moderately deep water. As noted on p. 50, under *Chicoreus (Siratus) yaquensis* (Maury, 1917), the fauna at this locality suggests water depths of 150 to 350 m.

Comparisons.—*Siphonochelus (Laevityphis) spinirectus*, n. sp., is unlike any other in the Dominican Republic. The only other species that has the same type of outward-directed spines and tubes is *Siphonochelus (Laevityphis) schencki* (Keen and Campbell, 1964) from the Aquitanian of Colombia. The latter is a much larger species, with a marked angulation in the varix anterior to the shoulder spine. Also in the older species the tubes are not parallel to the varical spines but are turned more adapically, giving an undulating appearance to the alternation of tubes and spines.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1210); Río Mao (TU 1292); Santiago area (TU 1227, 1227A, 1250, 1404, 1448, 1453; NMB 17266, 17270).

Distribution.—Gurabo Formation, Dominican Republic.

Genus PTEROTYPHIS Jousseau, 1880

Pterotyphis Jousseau, 1880, p. 336 (originally spelled as *Perotyphis*, but corrected by an unknown individual in *errata*, *Le Naturaliste*, Année 3, No. 43, p. 367, 1881).

Type species.—*Typhis pinnatus* Broderip, 1833, by original designation.

Remarks.—The genus *Pterotyphis* and its subgenus *Tripterotyphis* Pilsbry and Lowe, 1932, usually have been included in the subfamily Typhinae, due to the presence of the tubes between the varices or within the varices in the two groups, respectively. However, D'Attilio (1982, p. 94) has proposed that the presence of the tubes is due to convergence and that the two groups in question are more nearly allied with the Muricinae.

The shell structure in these two subgenera is certainly very like that of the typical muricine shell, with strong spiral cords and a scabrous appearance, in contrast to the typical typhine shell, which is almost smooth, with no more than a few weak spiral lines, or some type of wrinkled surface. This, combined with the presence of only three varices, in contrast to the four varices usually present in the Typhinae, is a strong reason for suspecting that the tubes do represent convergence.

The idea that the tri-alate typhines are really Muricinae in disguise was first suggested by Fleming, in his description of *Nothotyphis* Fleming, 1962 (p. 117), which he simply noted "does not closely resemble the American species of *Tripterotyphis*", making it instead a subgenus of *Pterynotus* Swainson, 1833. Subsequent authors (e.g., Gertman, 1969; Ponder, 1972, p. 220; Radwin and D'Attilio, 1976, p. 203) have placed *Nothotyphis* and *Tripterotyphis* in synonymy, but in the Typhinae rather than Muricinae.

D'Attilio's study compared the radulae of several of the supposed typhine genera and concluded that *Pterotyphis*, *Tripterotyphis*, and *Prototyphis* Ponder, 1972, should be reassigned to the Muricinae. Certainly *Prototyphis* is muricine; in fact, I consider it a synonym of *Pterochelus* Jousseaume, 1880. The radulae of the two type species (see Ponder, 1972, text-fig. 1-2; text-fig. 2-16) are indistinguishable and the shells are strikingly similar.

The radula of *Tripterotyphis* has been figured (Ponder, 1972, text-fig. 2-18; Radwin and D'Attilio, 1976, text-fig. 148; D'Attilio, 1982, fig. 13) and the rachidian plate is shown as distinctly three-dimensional, most closely resembling that of the subfamily Muricopsinae. To my knowledge there is no illustration available of the radula of *Pterotyphis*, but it is assumed to be like that of *Tripterotyphis*.

The remainder of the typhine genera have a variety of different radular types (as shown in Radwin and D'Attilio, 1976, text-figs. 140-156) and each is as different from the others as it is from the Muricinae. In truth, as D'Attilio (1982, p. 97) notes, there is no such thing as a "typical" typhine radula. Thus, the entire collection of genera that are united into the subfamily Typhinae may all represent convergence. The presence of tubes may be no more significant than the presence of alate varices or spines.

As noted above, D'Attilio has suggested that the genus *Pterotyphis* with its typically muricine cancellate surface ornamentation, its three varices, and its unsealed siphonal canal is better placed with the Muricinae, and the anal tubes represent convergence.

From a geological point of view, however, the genus *Pterotyphis* is as ancient as most of the family and there is no muricine ancestral form to which it can be readily related. Therefore, the case for convergence in the tri-

varicate, cancellate shells is as compelling as that for convergence in the tubes.

Inasmuch as the radular evidence does not overwhelmingly support the placement of *Pterotyphis* and *Tripterotyphis* with the genus *Pterynotus* (as it does for *Prototyphis*, for example), it seems best at this time to leave these two groups in their accustomed systematic place, with the realization that they may not be bona fide members of the Typhinae.

Subgenus **PTEROTYPHIS** *sensu stricto*

Pterotyphis (Pterotyphis) pinnatus (Broderip)

Plate 9, figures 4, 5

Typhis pinnatus Broderip, 1833, p. 178; Sowerby, 1841a, pl. 200, figs. 10, 11.

Typhis fordii Pilsbry, 1943, p. 40, pl. 7, fig. 4.

Pterotyphis (Pterotyphis) pinnatus (Broderip). Gertman, 1969, p. 183, pl. 8, fig. 2.

Typhis (Pterotyphis) pinnatus (Broderip). Bayer, 1971, p. 169, fig. 37D.

Pterotyphis pinnatus (Broderip). Radwin and D'Attilio, 1976, p. 197, pl. 30, fig. 2.

Typhis testa alba, fusiformi, trifariam pinnata, transversim striata, striis frequentibus, interstitiis punctatis; labri limbo crenulato . . .

The sides of the canal in the specimen are broken, but the canal does not appear to have been entire close to the aperture, though the sides of it approximate there very nearly. (Broderip, 1833, p. 178)

Description.—

Shell small, elongate; protoconch rounded, smooth, of one and one-half whorls; six post-nuclear whorls; three convex varices per whorl, each crossed by 12 crenulations; outer lip wide, of one part, flanged and crossed by 12 ribs, the anterior ones divided into primary ribs flanked on either side by one weaker rib; shell ornamented by strong spiral sculpture and sharp varices; axial growth lines giving a cancellate appearance to the surface of the shell; tubes nearer to succeeding than preceding varices, attached but not soldered to the varix; tubes made of two parts: an inner circular tube, surrounded by a striated flange that appears to be wrapped around the tube with a distinct suture line on the adapertural side of the tube; tubes pointing abaxially, abaperturally, and apically; aperture ovate, with a sinuous outer margin; anterior canal open with a narrow slit, curving to the right and abaperturally. (Gertman, 1969, p. 183)

Diagnosis.—Typhine with three winged varices per whorl; anal tube in each intervarical area. Shell surface covered with cancellate ornamentation. Aperture almost entire, smooth. Siphonal canal long, narrow, slightly recurved dorsally; not sealed over.

Holotype.—Not found.

Measurements (in mm, unless otherwise stated).—

specimen	height	diameter	locality
Holotype ¹	% in ²	⅔ in ²	(see above)
USNM 323905	20.4	8.7	TU 1277
NMB H 16999	11.8 ³	7.6	NMB 15849

¹ not found; ² *vide* Broderip, 1833; ³ incomplete

Type locality.—Recent; New Providence Island (Nassau), Bahama Islands (restricted by Gertman, 1969, p. 183).

Material.—Two specimens, from the shallow-water facies of the Gurabo Formation.

Remarks.—Two specimens of the Recent species *Pterotyphis* (*Pterotyphis*) *pinnatus* (Broderip) were found in the more shallow facies of the Gurabo Formation on the Río Gurabo. Data on the species suggest that it normally occurs in depths of approximately 50 m. In the TU collections there are Recent examples dredged from that depth off Panama (see Gertman, 1969, p. 183), as well as examples from the Pleistocene Moín Formation of Costa Rica (locs. TU 953, 954), where it occurs with *Murex* (*Haustellum*) *olssoni* Vokes, 1967a, another species that usually is found at about 50 m. Bayer (1971, p. 169) reported a single specimen from off Colombia in 37 m.

Comparisons.—As there are but three species of this subgenus presently known, comparisons are not difficult. The oldest reported is that from the Chipola Formation, *Pterotyphis* (*Pterotyphis*) *calhounensis* Gertman, 1969, which has a much coarser surface ornamentation. The only living species other than *P. pinnatus* is *Pterotyphis* (*Pterotyphis*) *fimbriatus* (Adams, 1854), from the west coast of Mexico, a larger and more expansively winged form than *P. pinnatus*, but basically very similar.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1277; NMB 15849).

Distribution.—Gurabo Formation, Dominican Republic. Moín Formation, Costa Rica; Pleistocene. Caribbean Sea and western Atlantic; Recent.

Subgenus **TRIPTEROTYPHIS** Pilsbry and Lowe, 1932

Tripterotyphis Pilsbry and Lowe, 1932, p. 78.

Type species.—*Typhis lowei* Pilsbry, 1931, by original designation.

Pterotyphis (**Tripterotyphis**) **triangularis** (Adams) Plate 9, figure 6

Murex cancellatus Sowerby, 1841a, pl. 190, fig. 79; Sowerby, 1841c, p. 143 (non *Murex cancellatus* Gmelin, 1791).

Typhis triangularis Adams, 1855c, p. 124.

Pterotyphis (*Tripterotyphis*) *triangularis* (Adams). Gertman, 1969, p. 186, pl. 8, fig. 4.

Tripterotyphis triangularis (Adams). Radwin and D'Attilio, 1976, p. 204, pl. 30, fig. 7.

T. testa fusiformi, triangulari, alba, subcancellata, varicibus tribus pinnatis postice tubulatis, interstitiis transversim latis in medio nodosis; apertura ovali canali mediocri aperto dextrorso subreflexo. (Adams, 1855c, p. 124)

Description.—

Shell medium-sized; five post-nuclear whorls; three varices and tubes per whorl; tubes within the varices, pointing apically, abaxially, and abaperturally; varices convex, crenulated, crossed by three ribs; outer lip of constant width, crossed by three ribs; a partition above the aperture joining the varix to the corresponding varix of the preceding whorl; shoulder formed only above the varices; suture appressed in the interapertural areas and distinct above the varix; shell crossed by coarse spiral ribs; aperture ovate, pointed anteriorly, surrounded with a raised rim with a sinuous outer margin; anterior canal closed, broad, curving abaperturally. (Gertman, 1969, p. 186)

Diagnosis.—Typhine with three winged varices per whorl, each with anal tube incorporated at the shoulder. Shell surface covered with spiral cords causing deep pits to be formed on both ad- and abapertural sides of varices. Aperture almost entire, smooth. Siphonal canal long, broad, recurved dorsally; partially sealed over.

Holotype.—BMNH 1961140.

Type locality.—Recent; Cabo Catoche, Quintana Roo, Mexico (restricted by Gertman, 1969, p. 186).

Material.—Four incomplete specimens, all from the shallow-water facies of the Gurabo Formation.

Measurements (in mm).—

specimen	height	diameter	locality
BMNH 1961140 ¹	24.3	12.9	(see above)
USNM 323906	14.0 ²	10.1	TU 1449

¹ holotype; ² incomplete

Remarks.—Four incomplete specimens document the occurrence of the living western Atlantic species *Pterotyphis* (*Tripterotyphis*) *triangularis* in the shallow-water beds of the Gurabo Formation. In the Recent fauna the species usually occurs in coralline habitats such as the eastern coast of Yucatan and the Bahama Islands. The only depth record reported (Gertman, 1969, p. 186) is 17 fm (31 m) and this is consistent with the other elements of the fauna at locality TU 1354 (see Saunders, Jung, and Biju-Duval, 1986, textfig. 15), the basal Gurabo Formation, and locality TU 1449, the gravity flow at La Barranca.

Comparisons.—Although all of the species of *Tripterotyphis* have a strong similarity, the greatest resemblance to *Pterotyphis* (*Tripterotyphis*) *triangularis* is not seen in *P. lowei* (Pilsbry, 1931), as Gertman (1969, p. 186) indicated, but with *Pterotyphis* (*Tripterotyphis*) *arcana* DuShane, 1969, another eastern Pacific species. These two cognate forms alone have two strong spiral cords, in contrast to the other species of the subgenus that have only one strong cord at the shoulder. They also have a less well-developed partition, causing the anal tubes to have a more spine-like appearance.

The only other western Atlantic species is *Pterotyphis* (*Tripterotyphis*) *vokesae* Gertman, 1969, from the Chipola Formation, which most closely resembles the

eastern Pacific species *Pterotyphis* (*Tripterotyphis*) *fayae* Keen and Campbell, 1964, both of these differing from *P. triangularis* in having more numerous and finer spiral cords.

Occurrence.—Gurabo Formation: Río Cana area (TU 1354); Santiago area (TU 1449).

Distribution.—Gurabo Formation, Dominican Republic. Bermont Formation, Florida; Pleistocene. Caribbean Sea and western Atlantic; Recent.

Subfamily THAIDINAE Jousseaume, 1888*

Remarks.—There is a question as to the validity of separating the group of Thaidinae as a family Thaididae, distinct from the Muricidae. Among current workers there is no agreement; both taxa have been used about equally. Harasewych (1984), on the basis of a study of the anatomy of four representative species, takes the position that the Thaididae are geologically the oldest group and anatomically the most primitive; therefore, they should be accorded a taxonomic status equal to the Muricidae. On the other hand, Fujioka (1985a, 1985b) studied sexual dimorphism and age changes in radulae in the Thaidinae and showed that in certain genera (e.g., *Mancinella* Link, 1807) there is a change from what would be considered a typical "thaidid" radula, with pentacuspitate rachidian tooth to a typically "muricid" tricuspidate tooth between juvenile and adult.

Thus, it seems evident that there is a group of characters, which are "primitive" and which are found in those forms assigned to the Thaididae/nae, and a group of "advanced" characters that are found in the Muricidae. The characters usually attributed to the "advanced" Muricidae include an extended siphonal canal, expanded varices, aragonitic shells, an operculum with a terminal nucleus ("muricoid" operculum) and a rachidian tooth with three major cusps ("muricine" rachidian tooth). The "primitive" thaidid characters would include a short to non-existent siphonal canal, no varices, calcitic shells, an operculum with a lateral nucleus ("purpuroid" operculum) and a rachidian tooth with five major cusps and numerous accessory denticles.

Unfortunately, there are a number of intermediate forms that cause this simple black-and-white picture to become shaded in gray. There are species in such genera as *Attiliosa* Emerson, 1968, and *Calotrophon* Hertlein and Strong, 1951, that have virtually no varices but have all the other muricine characters. A large group of species that have been much misunderstood

by past workers will be grouped in the subfamily Ergalataxinae Kuroda and Habe, 1971, in a future work. These genera have muricine radulae, opercula with a sub-lateral nucleus (truly intermediate between the muricoid and the purpuroid types), and aragonitic non-varicate shells.

In view of the almost unbroken spectrum of characters seen between the Muricinae and the Thaidinae, the logical answer would seem to be that the differences between the two are not sufficiently distinct to warrant more than subfamilial rank. As interpreted herein, the subfamily Thaidinae comprises those genera that have calcitic shells, "purpuroid" opercula, and usually pentacuspitate rachidian teeth. *Usually* the shells are non-varicate, just as *usually* the Muricinae and Muricopinae have varices.

Cossmann (1903) was the first to segregate the family Muricidae into the subfamilies that are customarily used today. According to him, the subfamilies are: Muricinae, with an operculum having an apical nucleus; Ocenebrinae, operculum with a lateral nucleus; Trophoninae, operculum with lateral or sub-lateral nucleus; Typhinae, operculum near Muricinae but having tubes; and Rapaninae, with a purpuroid operculum but a siphonal canal and aperture more like the Muricinae. The family Purpuridae (= Thaididae) he felt was so distinct that it should be accorded full familial rank.

His principal differentiation between the two families, however, was the "muriciforme" shell vs. the "purpuriforme" shell. Thus, the members of the Ocenebrinae with their long canal and varices were placed in the Muricidae, in spite of Cossmann's own observation that, although the shell is "franchement muricoïde", the operculum is "à peu près identique à celui de *Purpura*" (Cossmann, 1903, p. 7). Likewise, he conceded that the Rapaninae were transitional between *Murex* Linné, 1758, and *Purpura* Bruguière, 1789 having a purpuroid operculum. But because of the extended siphonal canal, he felt it belonged with the Muricidae. On all other bases it belongs with the Thaidinae. The radula is extremely modified; however, this is also seen in a number of thaidine genera, including *Drupella* Thiele, 1925, and *Nassa* Röding, 1798, and of itself does not seem to denegate placement in the Thaidinae. If anything it confirms placement in this group in which variability is the hallmark.

If one admits that there is considerably more variation in the nature of varices and siphonal canal than did Cossmann, it seems much more reasonable to include the Ocenebrinae with the other Thaidinae. Although certain of the genera presently included in the group are varicate (e.g., *Pteropurpura* Jousseaume, 1880), these have all of the other thaidine characteristics: calcitic shell; "purpuroid" operculum; and radula. Should one prefer to treat the Thaidinae as a full

* In Opinion 886 (ICZN, 1969), the *International Commission on Zoological Nomenclature* conserved the name *Thaididae/nae* over the technically older but less frequently used *Purpuridae/nae* and also conserved the amended spelling as classically correct.

family, perhaps the Ocnebrinae might be segregated as a subfamily within Thaididae.

The idea of varicate thaidids is not without precedent. Radwin and D'Attilio (1976, p. 176) "eliminated from consideration" in the Trophoninae several genera that have radulae "characteristic of the family Thaididae." These include *Austrotropon* Dall, 1902, *Forreria* Jousseaume, 1880, and *Zacatrophon* Hertlein and Strong, 1951. If these can be accepted as thaidines, then certainly there should be no difficulty with *Pteropurpura* and its allies. Anyone who can place *Murex tribulus* Linné, 1758, and *Attiliosa nodulosa* (Adams, 1855b) in the same subfamily should not have any problem.

Genus **THAIS** Röding, 1798

Thais Röding, 1798, p. 54.

Type species.—*Thais lena* Röding, 1798 [= *Murex fucus* Gmelin, 1791 = *Nerita nodosa* Linné, 1758], by subsequent designation, Iredale, 1915.

Subgenus **THAISSELLA** Clench, 1947

Thaisella Clench, 1947, p. 69.

Type species.—*Purpura trinitatensis* Guppy, 1869, by original designation.

Thais (Thaisella) trinitatensis (Guppy)

Plate 11, figure 2

Purpura trinitatensis Guppy, 1869, p. 366; Guppy, 1878, p. 179, pl. 7, fig. 17 [reprinted by Harris, 1921, p. 248, pl. 9]; Guppy, 1875, p. 50.

Not *Purpura trinitatensis* Guppy. Dall and Simpson, 1901, p. 411 [? = *Thais (Stramonita) rustica* (Lamarck, 1822)].

Thais (Thaisella) trinitatensis (Guppy). Clench, 1947, p. 69, pl. 34, figs. 1 (neotype), 2-4; Rios, 1985, p. 91, pl. 32, fig. 398.

Not *Thais (Thaisella) trinitatensis* (Guppy). Macsotay I., 1968, p. 93, pl. 2, figs. 4, 5 [= *Thais (Thaisella) coronata* (Lamarck, 1822)].

Thais (Thaisella) coronata (Lamarck, 1822). Rios, 1970, p. 83, pl. 24; Rios, 1975, p. 91, pl. 26, fig. 379 (including *T. trinitatensis* in synonymy; not of Lamarck, 1822).

Description.—

A solid ovate yellowish subumbrate shell adorned with numerous rounded spiral ridges which are crossed by fine imbricating striae. Whorls about 6, with 4 spiral rows of obtuse elongated tubercles, of which the two upper rows are much the largest, the superior one forming the angle of the whorls. Suture hidden by a row of stout curved and reflected lamellae, of which there are about 3 above each of the tubercles on the angle of the whorl. Spire conic, sharp. Mouth pink within and often ornamented with two or three more or less interrupted spiral red or chestnut lines corresponding to the external rows of tubercles. Aperture oval with a small and decided posterior canal forming the successive sutural lamellae; anterior canal open and a little reflected. Pillar lip smooth, flattened or hollowed out, bright pink; outer lip denticulate, obsoletely striate within. Height 40 millimetres, greatest breadth 27 mill., longest diameter of aperture 26 mill. (Guppy, 1869, p. 366)

Shell 35 to 45 mm (1½ to 1¾ inches) in length, rather heavy, solid and coarsely sculptured. Whorls convex, angular at the shoulder and six to seven in number. . . . Spire moderately extended, and produced at an angle of 72° to 82°. Suture indistinct. Aperture subcircular to elliptical. Posterior canal or anal notch well-developed, occasionally margined on the parietal wall with a well-defined ridge which follows back within the aperture. Anterior (siphonal) canal deep and recurved, its successive growth stages producing a broad umbilical area with the small opening rimate or evenly circular, but only extending a short distance within. Outer lip slightly thickened and finely crenulated. Parietal wall heavily glazed, sometimes ridged over the basal margin. Columella nearly straight and rounded in contour. Sculpture consisting of from one to four nodulose spiral ridges, the shoulder ridge being the most prominent. In addition, there are numerous spiral threads. Axial sculpture consists of very fine imbricated growth lines which cross the nodules and fine spiral threads. At the suture the successive margins of the posterior canal remain as a series of large imbrications. (Clench, 1947, p. 70)

Diagnosis.—Thaidine with non-varicate shell; series of pointed knobs at the shoulder and a second row at the periphery. Aperture large, labium patulous, flaring anal notch; outer lip thin, lirate within. Siphonal canal short, broad, forming a large umbilicus.

Neotype.—MCZ 177755 (designated by Clench, 1947, p. 70).

Type locality.—Recent; Gulf of Paria, Trinidad.

Material.—Figured specimen.

Measurements (in mm).—

specimen	height	diameter	locality
MCZ 177755 ¹	43.5 ²	29 ²	(see above)
NMB H 17006	41.4	28.7	NMB 16841

¹ neotype; ² *vide* Clench, 1947

Remarks.—*Thais (Thaisella) trinitatensis* is often confused with the similar species *T. coronata* (Lamarck, 1822) and locality records are not reliable. According to Clench (1947, p. 71), it is distributed along the mainland of Central America from Panama as far north as Guatemala; however, in the Tulane University collections from this entire area, especially Costa Rica and Panama, there are no specimens whatsoever.

Clench (1947, p. 69) placed the subspecies *Purpura coronata brujensis* Smith, 1946, in the synonymy of *T. trinitatensis* and consequently added Panama (type locality of *T. brujensis*) to the range of *T. trinitatensis*. However, the material he figures in justification of this synonymy (Clench, 1947, pl. 34, figs. 3, 4) clearly shows that *T. brujensis* is, rather, a synonym of *T. coronata*, characterized by a large flaring anal notch. There are identical examples of *T. coronata* from West Africa.

The only certain localities for *T. trinitatensis* are northern South America, from Venezuela (including Trinidad, which geologically, if not politically, is a part of Venezuela) to Brazil. The only record in the Greater Antilles is a single specimen reported by Dall and Simpson (1901, p. 411) from the Caballo Blanco Reef, Vieques, Puerto Rico. From their description it seems

likely that they actually had *Thais* (*Stramonita*) *rustica* (Lamarck, 1822) (which they also cited as *Purpura haemastoma* var. *undata* Lamarck), and not *T. trinitatensis*.

Thus, it was most unexpected to identify a single specimen from the Cercado Formation along the Río Cana as *T. trinitatensis*. In the pre-Pleistocene the fauna of the Dominican Republic may have been more similar to northern South America. From the raised beaches in Lago Enriquillo, on the south side of the island, David G. Robinson, formerly of the Museo Nacional de Historia Natural, Santo Domingo, has collected numerous examples of *T. coronata* which, although primarily a West African form, does occur in Trinidad (Macosotay I., 1968, figs. 4–7 [figs. 4, 5 as *T. trinitatensis*; figs. 6, 7 as *T. coronata*]), Panama (Smith, 1946, as *T. brujensis*), and Brazil (Clench, 1947, pl. 35, figs. 1, 2).

Comparisons.—*Thais trinitatensis* is closely related to the West African species *T. coronata* and may prove to be a synonym, as it has been considered by Rios (1970; 1975). However, all material examined suggests that the differences, though subtle, are consistent. The major difference is the presence in *T. coronata* of a very pronounced anal notch, one that is almost closed off by a subsutural constriction. Although *T. trinitatensis* has an anal notch, which produces the series of flutings or scales along the suture that caused Clench (1947, p. 69) to erect the subgenus *Thaisella*, it is not as well developed or as constricted as in *T. coronata*. In addition, the spiral sculpture is finer and more scabrous in *T. trinitatensis*; the shell is more attenuated and does not develop the large knobby projections seen in *T. coronata*.

The figured specimen (NMB H 17006 [Pl. 11, fig. 2]) appears to be smoother than the typical form with its noticeable remnants of old anal notches, but the specimen is worn; these remnants are present but hard to see in a photograph.

Occurrence.—Cercado Formation: Río Cana (NMB 16841).

Distribution.—Cercado Formation, Dominican Republic. (?) Guatemala to northern Brazil; Recent.

Thais* (*Thaisella*) *santodomingensis

Pilsbry and Johnson

Plate 11, figure 3

Thais santodomingensis Pilsbry and Johnson, 1917, p. 169; Pilsbry, 1922, p. 354, pl. 28, figs. 8, 9.

Thais (*Thaisella*) *santodomingensis* Pilsbry and Johnson, Clench, 1947, p. 71

Description.—

The shell is somewhat biconic, with short, straightly conic spire and weakly angular periphery. Suture bordered below with an irregular,

somewhat scabrous rounded ridge or welt; a somewhat nodose low rounded ridge runs in the anterior concavity. Sculpture of numerous vertical ribs on the upper and middle part of the whorls, strongest at the periphery, ten on the last whorl, and many spiral cords in strong relief. Siphonal fasciole prominent, umbilical crevice open. The aperture has a shallow posterior channel and the usual deep anterior notch. Columella is heavy rounded and straight. (Pilsbry and Johnson, 1917, p. 169)

Diagnosis.—Thaidine with non-varicate shell; only vague axial ridges. Aperture large, labium patulous, flaring anal notch; outer lip lirate within. Siphonal canal short, broad, forming small umbilicus.

Holotype.—ANSP 3187.

Type locality.—Locality unknown; Gabb Collection, Dominican Republic.

Material.—Holotype.

Measurements.—ANSP 3187 (holotype); height 45.5 mm, diameter 30.8 mm; locality unknown.

Remarks.—A battered specimen from the Gabb Collection was named by Pilsbry and Johnson (1917, p. 169) as *Thais santodomingensis*. There is an even more battered and rolled specimen from the shallow-water gravity flow on the Río Verde (loc. TU 1250; see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 38) that seems to be referable to this species. Otherwise no stratigraphic information can be added to the original description. In both the TU collection shell and the holotype the aperture is filled with an indurated matrix of sand and gravel, suggesting that it was taken from a concretionary layer, such as those common in the Cercado Formation.

Comparisons.—Although Pilsbry and Johnson compared *Thais santodomingensis* with the Recent species *T. coronata* (Lamarck, 1822), there is only a subgeneric resemblance to the latter species, which has a peculiar distorted appearance. The type specimen of *T. santodomingensis* has a much more biconic outline, with numerous fine spiral cords, in contrast to the almost square outline of *T. coronata*, which bears two spiral rows of rounded knobs.

From the other Dominican species of *Thais* (*Thaisella*), *T. (T.) trinitatensis*, *Thais* (*Thaisella*) *santodomingensis* differs in having a longer, narrower shell outline and a smaller umbilicus, with a row of spines marking the base of the body whorl. Clench (1947, p. 71) suggested that *T. santodomingensis* might be ancestral to *T. trinitatensis*. However, as there is a good example of *T. trinitatensis* from the Cercado Formation also, this is not likely to be the case unless the type of *T. santodomingensis* came from older strata such as the Baitoa Formation. The matrix in Baitoa specimens is sometimes as hard as that of this one, but it has a very different appearance under the microscope, with many shell fragments, and a darker color overall.

Occurrence.—Gurabo Formation: Santiago area (TU 1250).

Distribution.—?Cercado and Gurabo formations, Dominican Republic.

Subgenus STRAMONITA Schumacher, 1817

Stramonita Schumacher, 1817, p. 226.

Type species.—*Buccinum haemastoma* Linné, 1758, by subsequent designation, Gray, 1847.

Thais (Stramonita) quadridentata, new species
Plate 11, figures 4–7

Etymology of name.—*L. quadri* = four + *L. dentatus* = toothed.

Description.—Shell with five teleoconch whorls in adult; protoconch unknown. Spiral ornamentation of major and minor cords, arrangement irregular but usually each major cord flanked by a pair of minor cords; beneath these and covered by them, four or five raised spiral ridges, better developed in some examples than others: one at shoulder, one at periphery, two or three on anterior portion of body whorl, one on siphonal canal. Axial sculpture of growth lamellae, forming scales on spiral cords and, especially, in the interspaces; eight to 10 vague axial ridges, best seen at intersections with spiral ridges, here small nodes developed, stronger on earlier whorls, evanescent with growth in some examples, persisting in others. Aperture ovate, labium wide, impressed into umbilical area, often with small lirae at anterior end; large ridge at posterior end, extending well into aperture, delineating a small anal notch. Outer lip patulous in anterior portion, slightly thickened, with four (rarely five) elongate denticles reflecting the area between the major spiral ridges. Suture appressed, crossed by a series of scales marking the positions of former anal notches. Subsutural ramp sloping, little or no angle formed at shoulder. Siphonal canal short, broad, slightly recurved at distal end, forming a small umbilical chink.

Diagnosis.—Small thaidine with non-varicate shell, only small knobs, if any, formed along axial ridges. Aperture large; labium appressed, lirate; small anal notch; outer lip thickened, four or five denticles within. Siphonal canal short, broad, forming small umbilical chink.

Holotype.—USNM 323917.

Type locality.—Locality TU 1378, Cercado Formation; Río Gurabo, west side, at high bluff about 1 km above mouth of Arroyo La Caba, or approximately 6.6 km (airline) above the ford on Los Quemados–Sabaneta road, Dominican Republic (see Saunders, Jung, and Bijou-Duval, 1986, text-fig. 5).

Material.—A total of 17 specimens, all from the lower beds of the Cercado Formation.

Measurements (in mm).—

<i>specimen</i>	<i>height</i>	<i>diameter</i>	<i>locality</i>
USNM 323917 ¹	26.6	16.6	TU 1378
NMB H 17007 ²	24.4	16.0	NMB 16844
Marcano coll., unnumbered			
Dom. Rep. ³	25.8	17.5	TU 1358
USNM 323918 ⁴	27.4	17.8	TU 1358
PRI 33059 ⁵	32.2	29.3	TU 1377

¹ holotype; ² paratype A; ³ paratype B; ⁴ paratype C; ⁵ unfigured paratype

Remarks.—In the lower beds of the Cercado Formation there are specimens of a thaidine that externally would seem to be the same as the Recent Caribbean species *Thais (Stramonita) rustica* (Lamarck, 1822); however, they invariably have but four or five strong denticles on the inner side of the outer lip and are here named *Thais (Stramonita) quadridentata*.

In addition to the Dominican specimens there is one other example of this form in the TU collections. It comes from the lowermost (and most shallow-water) Gatun Formation of Panama, at locality TU 1432, near Cativá, Panama. The extremely shallow habitat of thaidines in general is the principal reason for the lack of a better-documented fossil record. All but one of the specimens in the type lot of *T. quadridentata* came from the shallow-water beds of the Cercado Formation along the upper reaches of the Río Gurabo.

Comparisons.—The presence of four denticles on the inner side of the outer lip immediately suggests that the Dominican Republic specimens should be referred to *Thais (Stramonita) bicarinata* (Blainville, 1832), a species confined, so far as known, to the islands of St. Helena and Ascension in the southern Atlantic Ocean. Clench (1947, p. 82, pl. 39, figs. 7, 11, 12) considered *T. bicarinata* to be a subspecies of *T. rustica*, a common Caribbean form. But, examination of the types of Blainville's species in the Museum National d'Histoire naturelle, Paris, shows that species to be more closely related to *Thais (Stramonita) haemastoma* (Linné, 1758), differing from the latter in the presence of the four denticles rather than a finely lirate aperture.

The Dominican Republic species is most closely related to *T. rustica*. One might say that *T. bicarinata* is to *T. haemastoma* as *T. quadridentata* is to *T. rustica*. Both *T. rustica* and *T. quadridentata* have the ornamentation marked by four or five raised spiral ridges; in *T. haemastoma* and *T. bicarinata* the shell surface is ornamented by subdued cords only.

In overall appearance *T. quadridentata* is about the same shape and size as *T. rustica*, but the surface ornamentation is more scabrous and there are but four denticles on the inner lip in contrast to the numerous strong lirae on the inner side of the lip in *T. rustica* (compare Pl. 11, figs. 4a, 5a, 6a, 7a, with Pl. 11, fig. 8).

In the Agueguexquite Formation of Mexico (loc. TU 1046) and in the Río Banano Formation of Costa Rica (loc. TU 1268), both of which are correlative with the Gatun Formation, there are specimens of *T. rustica*. Another specimen of *T. rustica* was described as *Cymia caloosana* Tucker and Wilson, 1933 (p. 71, pl. 11, fig. 8), from beds at Port Mayaka, Florida, probably also of the same mid-Pliocene age. So the time of separation goes back that far, at least. The presence of four denticles seems to be a primitive condition, as there are many fossil species in Europe (see Bellardi, 1882, pl. 11, figs. 1-4, 10, 13, all of which he gave species names, but all of which are probably the same, considering the variability of thaidines) that have this same number. It may well be that *T. quadridentata* is directly ancestral to *T. rustica*, but the lines may also have developed independently. Not enough is known about the fossil history of the genus to be certain.

Occurrence.—Cercado Formation: Río Cana (NMB 16844); Río Gurabo (TU 1231, 1358, 1359, 1377, 1378).

Distribution.—Cercado Formation, Dominican Republic. Gatun Formation, Panama; Pliocene.

Genus *SPINIDRUPA* Habe and Kosuge, 1966

Spinidrupa Habe and Kosuge, 1966, pp. 315 (Japanese), 330 (English).

Type species.—*Murex euracanthus* Adams, 1853, by original designation.

Spinidrupa radwini, new species

Plate 9, figure 2

Etymology of name.—Named for the late George E. Radwin, in honor of his work on the muricid radula.

Description.—Shell hexagonally prismatic in outline; six post-nuclear whorls and a protoconch of three-and-one-half granulose whorls, ending at a sharp varix. Shell non-varicate; axial ornamentation beginning on first post-nuclear whorl with nine ridges, each bearing a prominent node just above the suture; eight or nine nodes on each succeeding whorl. On the body whorl axial ridges marked by strong nodes at the shoulder and at the line of constriction into the siphonal canal, plus an additional two rows of smaller nodes on the canal. Spiral ornamentation of a single cord on the early whorls gradually adding threads to become approximately nine equal cords on the penultimate and about 30 on the body whorl and canal. These spiral cords bearing numerous scalar lamellae, marking axial lines of growth, and giving a scabrous appearance to the shell surface, especially between the rows of nodes. Suture appressed, sinuated by the nodes of previous whorls. Aperture elongate, with strong anal sulcus, delineated by a small denticle at the posterior end of the

columellar wall; with four strong denticles on the inner side of outer lip, the strongest at the midline, the second largest at the constriction of the body whorl into the siphonal canal. Columellar lip free-standing, at the anterior end two or three small denticles. Terminal varix inconspicuous, marked only by the swollen nodes on the spiral cords. Siphonal canal short, broad, open as a narrow slit, recurved at the distal end; small umbilicus formed by terminations of previous canals.

Diagnosis.—Small thaidine with non-varicate shell, nine axial ridges nodulated by spiral cords. Aperture narrow; labium with a few small denticles at anterior end, labrum strongly denticulate; deep anal sulcus. Siphonal canal short, broad, recurved at distal end.

Holotype.—USNM 323903.

Type locality.—Locality TU 1215, Gurabo Formation; Río Gurabo, bluffs on both sides, from the ford on the Los Quemados-Sabaneta road upstream to approximately 1 km above the ford, Dominican Republic (= locs. USGS 8539-8543; Maury's Zone D; Saunders, Jung, and Biju-Duval, 1986, text-fig. 5).

Material.—Nine specimens, from the shallow-water facies of the Gurabo Formation or the Cercado Formation.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323903 ¹	11.2	6.2	TU 1215
PRI 33057 ²	9.6	5.9	TU 1422

¹ holotype; ² unfigured paratype

Remarks.—*Spinidrupa radwini*, n. sp., is another of the Indo-Pacific elements of the Dominican fauna. Although no species of *Spinidrupa* have been reported in the New World prior to this report, there is no doubt of the assignment of *S. radwini*, n. sp., to that genus. The aperture with denticles on inner and outer lip, the strong anal notch, and the extremely scabrous surface ornamentation all agree with this assignment.

The occurrence of five specimens of the type lot at locality TU 1215 and two at locality TU 1422, both coralline localities, is also in accord with placement in this genus. Cernohorsky (1969, p. 310) says of *Spinidrupa spinosa* (Adams and Adams, 1853), the species that is most closely akin to *S. radwini*, "Habitat: On reefs, under coral rocks, in shallow water."

Comparisons.—The smaller size of this new species (maximum height 11.2 mm, holotype) is the principal feature distinguishing it from the Indo-Pacific species *S. spinosa*. The latter attains a height in excess of 25 mm and has moderately long spines instead of the rounded nodes of *S. radwini*. But the similarities between these two species far outweigh the differences. The two species have identical protoconchs, the same sloping subsutural area, covered by axial lamellae, the

same two rows of spiral cords that give rise to spines in *S. spinosa*, and nodes in *S. radwini* (most species have three such rows). In addition, the two species have identical labral denticles, with the posteriormost much larger than the others.

Occurrence.—Cercado/Gurabo formations: Río Cana area (TU 1422; NMB 16836); Río Gurabo (TU 1215); Santiago area (TU 1227A).

Distribution.—Cercado and Gurabo formations, Dominican Republic.

Spinidrupa demissa, new species

Plate 9, figure 3

Etymology of name.—*L. demissa* = hanging down or drooping.

Description.—Shell strongly biconic; protoconch of four-and-one-half granulose whorls, with a sharp spiral ridge immediately adjacent to the suture. Teleoconch beginning with a sharp arcuate varix, six post-nuclear whorls. Axial ornamentation on each teleoconch whorl consisting of eight open spines, set anteriorly on the whorl just above the appressed suture, which is sinuated by the axial swellings. Spiral ornamentation on early whorls of a single strong cord corresponding to the axial spines, plus numerous finer threads — four or five of these on the shoulder between the suture and the major cord and another two below the cord. On the body whorl a second slightly weaker major cord immediately anterior to that one visible on the earlier whorls, plus two more major cords on the siphonal canal. Numerous finer threads in the area between, and sometimes covering, the major cords. In addition, numerous fine axial lines of growth, giving a linen-like surface texture over the entire shell. Aperture elongate, strong anal sulcus formed by a rounded node at the posterior end of the columellar wall; inner side of outer lip with five denticles, that at the midline the largest; columellar lip free-standing, with two or three inconspicuous denticles at the anterior end. Terminal varix with four more or less open spines, corresponding to the major spiral cords, the posteriormost strongest and directed in an abapical direction. Siphonal canal short, open by a narrow slit, sharply recurved at the distal end; a small umbilicus formed by terminations of previous canals.

Diagnosis.—Small thaidine with extremely elongate shell, on each whorl eight varices each marked by a long spine at the shoulder, which is located at the periphery. Aperture narrow; labium with two or three small denticles at anterior end; labrum strongly denticulate; deep anal sulcus. Siphonal canal short, narrow, recurved dorsally.

Holotype.—USNM 323904.

Type locality.—Locality TU 1215, Gurabo Forma-

tion; Río Gurabo, bluffs on both sides, from the ford on the Los Quemados-Sabaneta road upstream to approximately 1 km above the ford, Dominican Republic (= locs. USGS 8539–8543; Maury's Zone D; Saunders, Jung, and Biju-Duval, 1986, text-fig. 5).

Material.—A total of 19 specimens, all from the shallow-water facies of the Gurabo Formation.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323904 ¹	7.3	3.7	TU 1215
PRI 33058 ²	6.9	3.3	TU 1215

¹ holotype; ² unfigured paratype

Remarks.—One of the more unusual forms found in the shallow-water portions of the Gurabo Formation is the tiny (maximum height 8 mm) elongated species here named *Spinidrupa demissa*, n. sp. As with its congener *S. radwini*, n. sp., there is no doubt as to its placement in this otherwise Indo-Pacific genus, but there is no known species to which it is closely related, including the sympatric *Spinidrupa radwini*.

Spinidrupa demissa, n. sp., is not especially rare; there are 19 specimens in the type lot (10 from locality TU 1215 or equivalent locs. NMB 15840, 15846; nine from loc. TU 1227A; Saunders, Jung, and Biju-Duval, 1986, text-figs. 5, 36) all from relatively shallow-water occurrences. One would think if there were a modern descendant that it would be known, but perhaps the small size has caused it to be overlooked.

Comparisons.—The only species to which *Spinidrupa demissa*, n. sp., bears the least resemblance is the Indo-Pacific type species of the genus, *Spinidrupa euracantha* (Adams, 1853). The latter is larger (maximum height about 20 mm), and has two rows of spines rather than the single row of *S. demissa*. The shoulder of *S. euracantha* is not as near the periphery as is that of *S. demissa*; nevertheless, there is a degree of similarity in the high-spined outline with the flattened shoulder spines. In addition, the protoconchs and apertures are identical. Certainly, there is no other species fossil or Recent to which this bizarre species may be compared.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1215; NMB 15840, 15846); Santiago area (TU 1227A).

Distribution.—Gurabo Formation, Dominican Republic.

Genus UROSALPINX Stimpson, 1865

Urosalpinx Stimpson, 1865, p. 58.

Type species.—*Fusus cinereus* Say, 1822, by original designation.

Hanetia Jousseaume, 1880, p. 335.

Type species.—*Murex haneti* Petit de la Saussaye, 1856, by original designation.

***Urosalpinx denticulatus*, new species**

Plate 11, figure 1

Etymology of name.—*L. denticulatus* = with small teeth.

Description.—Shell fusoid in outline, with five post-nuclear whorls in holotype; protoconch unknown. Spiral ornamentation beginning on first teleoconch whorl with two strong cords that become increasingly distant from suture with each successive turn. Weaker cords gradually added on subsutural ramp until body whorl and siphonal canal covered by numerous weak cords, with four somewhat stronger cords in a band between the periphery and the base of the siphonal canal. Axial ornamentation on first whorl of 12 equi-sized nodes, diminishing to from nine to 12 low, rounded ridges on each whorl thereafter. In addition, entire surface marked by undulating growth lines, best seen adjacent to suture. Nodes set very low on whorl, maximum diameter near midpoint of body whorl; shoulder sloping, appressed over suture. Aperture elongate-oval; outer lip slightly flared, not thickened; six elongate denticles well within; inner lip smooth, completely adherent to columellar wall. Siphonal canal short, broad, slightly recurved dorsally, partly covered but not sealed over by a flange of shelly material extending from adaxial side.

Diagnosis.—Thaidine with elongate non-varicose shell, having nine to 12 low axial ridges per whorl. Aperture ovate; labium smooth, labrum with six denticles within; anal notch not pronounced. Siphonal canal short, broad, open by narrow slit; almost straight.

Holotype.—NMB H 17005.

Type locality.—Locality NMB 16923, Cercado Formation; Río Mao at mouth of Arroyo Bajón, near Naranjo ó Bajón, Dominican Republic (= loc. TU 1379; Saunders, Jung, and Bijou-Duval, 1986, text-figs. 15, 32).

Material.—Holotype.

Measurements.—NMB H 17005 (holotype); height 31.0 mm, diameter 17.9 mm; locality NMB 16923.

Remarks.—The single specimen of *Urosalpinx denticulatus* is the only representative of the genus *Urosalpinx* in the Dominican Republic. In general, species of *Urosalpinx* tend to be temperate in habit and the genus has heretofore not been reported between approximately 23° N. and 23° S. latitude, or from southern Florida to Rio de Janeiro, Brazil. The presence of this new species in the tropical beds of the Cercado Formation is, therefore, of more than routine interest.

Recent species of the genus *Urosalpinx* are always inhabitants of shallow water, and in the North American area include the notorious "Oyster Drill", bane of the oysterman. Presumably the Cercado Formation

species maintained the generic tradition, for oysters occur throughout the formation.

Comparisons.—Morphologically *Urosalpinx denticulatus*, n. sp., is most nearly akin to the Brazilian *Murex haneti* Petit de la Saussaye, 1856, the type species of *Hanetia*, which is here considered a synonym of *Urosalpinx*. The principal difference between *Urosalpinx haneti* and the more northern species of the genus is the presence of six large denticles within the outer lip. The type of *Urosalpinx*, *U. cinereus*, may have denticles but never so large as those in species of *Hanetia* and in *U. denticulatus*, n. sp. A California species, *Ocenebra circumtexta* Stearns, 1872, which I refer to *Urosalpinx* because of its unsealed siphonal canal, has an aperture most like that of *U. denticulatus*, n. sp., but the shell of the former differs in having much stronger spiral ornamentation.

Occurrence.—Cercado Formation: Río Mao (NMB 16923).

Distribution.—Cercado Formation, Dominican Republic.

Genus *CYMIA* Mörch, 1860

Cuma Humphrey [sic]. Swainson, 1840, pp. 87, 307 (non *Cuma* Milne-Edwards, 1828).

Type species.—*Cuma sulcata* Swainson, 1840 [= *Buccinum tectum* Wood, 1828], by monotypy.

Cymia Mörch, 1860, p. 98 (substitute name for *Cuma* Swainson 1840, non Milne-Edwards, 1828).

Type species.—*Cuma sulcata* Swainson, 1840, by monotypy.

Tritonopsis Conrad, 1865, p. 20.

Type species.—*Triton subalveatum* Conrad, 1849, by monotypy.

Fasciolina Conrad, 1867, p. 186.

Type species.—*Fasciolaria woodii* Gabb, 1860, by monotypy.

Remarks.—The genus *Cymia* is first recorded in the Oligocene of South America, France, and Mississippi. *Purpura monoplex* Deshayes in Sandberger, 1861, from France, and *Triton subalveatum* Conrad, 1849, from Mississippi, are much alike, with a reticulate spire and strong spiral cords. Interestingly, the Dominican Republic species *C. henekeni* seems to be derived from the French species *C. monoplex*, which has shoulder nodes varying from strong to a simple keel, rather like the variations that are seen in *C. henekeni*. The completely unshouldered American species *C. subalveata* on the other hand, almost certainly gave rise to the equally unshouldered *C. woodii*, the latter differing from the Mississippi species in having much finer spiral ornamentation.

Conrad (1865, p. 20) named *Triton subalveatum* as type of *Tritonopsis*, a new genus of Tritoniidae (= Cy-matiidae). Woodring (1959, p. 223) suggested that *Tritonopsis* be retained as a subgenus of *Cymia*, being "characterized by a slightly notched siphonal canal, slightly swollen siphonal faciole, the persistence of reticulate sculpture to a late stage, and the absence of spines." But these traits are variable within the genus *Cymia*, particularly in *C. henekeni*. By this definition some specimens of *C. henekeni* would be placed in *Tritonopsis* and others in *Cymia sensu stricto*. Gabb noted that the species was extremely variable and added: "I have it with rounded body, without a tubercule, and varying from that to a broadly angulated and umbilicated form, with six immense tubercles on the angle." The latter (here figured, Pl. 12, fig. 3) was the variation separated by Pilsbry (1922, p. 355) as the subspecies *tectiformis*. But the rounded forms and the knobbed forms intergrade and occur at the same localities.

***Cymia henekeni* Maury**
Plate 12, figures 3–11

Cuma tectum Kiener [sic]. Gabb, 1873, p. 214; Guppy, 1876, p. 524 (not of Wood, 1828).

Cymia Woodii (Gabb). Dall, 1903, p. 155 (in part, not of Gabb, 1860).

Cymia henekeni Maury, 1917, p. 104(268), pl. 17(43), fig. 1; Vaughan and Woodring in Vaughan *et al.*, 1921, p. 113; Pilsbry, 1922, p. 355; Woodring, Brown, and Burbank, 1924, p. 183; Ramirez, 1956, p. 10, pl. 1, figs. 5, 6; Marciano F., 1981, p. 8.

Cymia n. sp. cf. *C. henekeni* Maury. Vaughan and Woodring in Vaughan *et al.*, 1921, p. 147.

Cymia henekeni tectiformis Pilsbry, 1922, p. 355, pl. 28, figs. 11, 12; Woodring, Brown, and Burbank, 1924, p. 183, pl. 15, figs. 8, 9.

Description.—Shell biconic; six teleoconch whorls; protoconch of two-and-one-half conical whorls, ending at a crescentic varix. Spiral ornamentation beginning with two strong flat-topped cords, forming a marked concavity between anteriormost cord and suture. By second teleoconch whorl a third cord added on shoulder ramp, immediately anterior to suture, plus numerous smaller threads intercalated between and on top of major spiral cords, in particular that at the shoulder, which is thereby divided into two; major cord at shoulder becoming increasingly prominent. By fourth teleoconch whorl the spiral ornamentation beginning to be flattened out, changing the appearance to that of a smooth shell with incised spiral lines, every second or third of these stronger and deeper than the others. Axial ornamentation on first three or four teleoconch whorls of approximately 20 ridges, the intersection of axial ridges and spiral cords giving strongly reticulate pattern; ridges gradually diminishing in number and strength, the adult shell having only a dozen, or less, very large axial nodes at shoulder, sometimes doubled;

more often becoming almost unnoded. Entire shell surface covered by axial lines of growth, as well as positions of former apertures, causing the unworn shell to be festooned with abaxially curved imbrications over each spiral cord. Suture channeled by a series of raised lamellar imbrications marking former positions of the large anal sulcus. Aperture elongate-oval, inner lip completely appressed; one strong plication on columella, at about the midpoint; another strong liration at posterior end of columellar lip, forming an anal sinus. Outer lip flaring, margin thin, with numerous small projecting spines, each one marking the termination of a major spiral groove; within the outer lip about 12 lirations, reflecting the same major spiral grooves, but separated from the projections by a smooth space along the outermost portion of the lip. Siphonal canal moderately long, broad, recurved at distal end; terminations of former canals forming a series of imbrications, giving rise to a small umbilicus, into which columellar lip is plastered.

Diagnosis.—Large non-varicate thaidine, with biconic outline, early whorls markedly reticulate, later whorls almost smooth with about 12 axial nodes at shoulder. Aperture narrow, labium appressed along entire length and into umbilical chink, one strong plait about midway, well-developed anal notch causing suture to be channeled; outer lip lirate within. Siphonal canal moderately long, broad, recurved dorsally.

Holotype.—PRI 28757.

Type locality.—Locality NMB 17283 (here restricted), Baitoa Formation; east side of Río Yaque del Norte, at Boca de los Ríos, just below the confluence of the Río Bao and the Río Yaque, Dominican Republic (Saunders, Jung, and Biju-Duval, 1986, text-fig. 21).

Material.—A total of 125 specimens all from the Baitoa Formation.

Measurements (in mm).—

specimen	height	diameter	locality
PRI 28757 ¹	49.7	32.0	unknown ²
ANSP 2794 ³	46.2	32.0	unknown ²
NMB H 17008	19.0	11.0	NMB 16935
NMB H 17009	46.6	30.0	NMB 17265
NMB H 17010	45.9	27.8	NMB 17283
NMB H 17011	40.0	27.0	NMB 16935
USNM 323921	34.6 ⁴	25.0 ⁴	TU 1226
USNM 323922	47.2	29.6	TU 1364
USNM 323923	19.0	12.4	TU 1226
USNM 369798	5.5	2.4 ⁴	USGS 9946 ⁵

¹ holotype; ² ex Gabb coll.; ³ holotype of *C. henekeni tectiformis*;

⁴ incomplete; ⁵ Ravine Roche Salée, at crossing of trail from Hinche to Thomassique, Haiti (see Woodring, Brown, and Burbank, 1924, p. 175)

Remarks.—The form originally referred by Gabb to the Recent eastern Pacific species *Cuma tectum* (Wood, 1828) and subsequently named by Maury as *Cymia*

henekeni is one of the most common gastropods in the Baitoa Formation. According to Pilsbry (1922, p. 355), there were over 100 specimens in the Gabb collection. Guppy (1876, p. 524) noted that the species is "well represented in the Geological Society's collection"¹⁹ and there are 125 specimens in the combined TU and NMB collections.

In addition to *Cuma tectum*, the species also has been referred to *Cymia woodii* (Gabb, 1860) by Dall (1890, p. 155). The latter, originally named as *Fasciolaria*, is a completely shoulderless *Fasciolaria*-like shell (see Pl. 12, fig. 12) that was named the type species of a genus of Fascioliidae by Conrad (1867, p. 186). The type specimen from the Mio-Pliocene Kirkwood Formation of Shiloh, New Jersey, however, represents a good species of *Cymia*, the lack of shoulder spines not being sufficient reason, in my opinion, to segregate the form subgenerically. Although certain specimens of *Cymia henekeni* do become nearly round-shouldered (see Pl. 12, fig. 7) there is always at least a trace of a keel at the periphery.

Comparisons.—*Cymia henekeni* may be distinguished from all other non-Oligocene species by the presence of the reticulated spire. Evidently this is a primitive character, as it is found only in the older forms. Presumably *C. henekeni* gave rise to two other species: *Cymia heimi* Hertlein and Jordan, 1927 (p. 627, pl. 18, fig. 5), from the Miocene Isidoro Formation of Baja California, with moderate shoulder nodes; and a new species in the Cercado Formation, *Cymia marcanoi*, which has greatly reduced nodes.

In northern South America and the eastern Pacific there is another group of species, beginning with the Peruvian Oligocene *Cymia berryi* Olsson, 1931 (p. 105, pl. 18, fig. 6), a strongly shouldered form. From this line are derived the several strongly shouldered forms found in the Cantaure Formation (early Miocene) and Urumacoa Formation (middle Miocene) of Venezuela, in the Pliocene of Panama and Trinidad, and the Recent species *Cymia tectum*.

Occurrence.—Baitoa Formation: Baitoa area (TU 1226, 1253, 1363, 1364; NMB 16935, 16936, 16938, 16941, 17280–17284, 17286–17290).

Distribution.—Baitoa Formation, Dominican Republic. Thomonde Formation, Haiti; early Miocene.

***Cymia marcanoi*, new species**

Plate 12, figures 1, 2

Etymology of name.—This new species is named in honor of Professor Eugenio de Jesus Marcano F., for-

mer Director of the Museo Nacional de Historia Natural, Santo Domingo, Dominican Republic, and long-time student of the Cercado Formation fauna, whose kindness during the years of our work in the Dominican Republic can never be repaid.

Description.—Shell biconical, with six teleoconch whorls; protoconch unknown. Spiral ornamentation of numerous flattened cords, many with a faint median groove. Entire shell surface crowded with minute axial growth lamellae, giving a fimbriated appearance as they curve over each spiral cord. Approximately 12 indistinct axial nodes, somewhat stronger on early whorls, weaker on later whorls. Subsutural ramp concave, appressed to the level of the shoulder of each previous whorl, suture sinuated by the axial nodes. Suture channeled on about first three whorls but appressed in adult stages. Aperture biconic, attenuated posteriorly into a sharply constricted anal notch, formed by subsutural ramp and a strong spiral ridge located immediately anterior to suture on inner lip; outer lip crenulated by small toothlike points projecting at the intersection of spiral grooves and edge of outer lip; inner side of outer lip with seven strong lirations, extending well into the aperture; inner lip completely appressed, smooth, with a single, strong, columellar plait approximately midway along its length. Siphonal canal moderately long, broad, recurved dorsally; small umbilicus.

Diagnosis.—Large biconic non-varicate thaidine, approximately 12 indistinct axial ridges. Aperture large, inner lip appressed along entire length, including umbilical chink, one plait midway along its length, narrow anal notch; outer lip with about seven strong lirations within. Siphonal canal moderately long, broad, recurved dorsally.

Holotype.—USNM 323919.

Type locality.—Locality TU 1376, Cercado Formation; Río Gurabo, east side, about 0.25 km above mouth of Arroyo La Cabra, or approximately 6 km (airline) above the ford on Los Quemados–Sabaneta road, Dominican Republic (Saunders, Jung, and Bijou-Duval, 1986, text-fig. 5).

Material.—The type lot of five specimens.

Measurements (in mm).—

specimen	height	diameter	locality
USNM 323919 ¹	50.0	32.3	TU 1376
USNM 323920 ²	34.5	22.0	TU 1358

¹ holotype; ² paratype

Remarks.—Inasmuch as specimens of *Cymia henekeni* abound in the Baitoa Formation and may be considered the best "guide-fossil" to that unit, it was somewhat disconcerting initially to discover rare specimens of *Cymia* in the younger Cercado Formation. However, examination proved them to be a new species

¹⁹ The Heneken Collection, which was sent to the Geological Society of London in 1848, and which was the basis for the molluscan descriptions of Sowerby (1850) and Guppy (1876).

here named *C. marcanoi*, which is sufficiently rare (five examples in all) that it is unlikely to ever be used as a guide to the formation. All but one have been taken in the shallow-water beds along the upper reaches of the Río Gurabo, in the area around Arroyo La Cabra. My husband and I were originally apprised of this locality by Professor Eugenio Marciano F., who has been collecting there for years, and we very much appreciate his sharing information and collections with us.

Comparisons.—*Cymia marcanoi*, n. sp., is similar to the older *C. henekeni* but consistently differs from that form in lacking the cancellate early whorls and the persistent channeled suture. In addition, *C. marcanoi* also differs from *C. henekeni* in having a less flaring outer lip with fewer interior lirations. The shoulder nodes are only weakly developed in all the specimens at hand and tend to be divided by a spiral groove that causes them to appear doubled. Other than *C. henekeni* there is no species known that has so weakly noded an appearance. *Cymia woodii* (Gabb, 1860) and *Cymia subalveata* (Conrad, 1849), which have no nodes whatsoever, lack the subsutural concavity of the Dominican species.

Occurrence.—Cercado Formation: Río Cana (TU 1301); Río Gurabo (TU 1231, 1358, 1376, 1419).

Distribution.—Cercado Formation, Dominican Republic.

Genus *VITULARIA* Swainson, 1840

Vitularia Swainson, 1840, p. 297.

Type species.—*Vitularia tuberculata* Swainson, 1840 [= *Murex miliaris* Gmelin, 1791], by monotypy.

Vitularia dominicana Vokes

Plate 11, figure 9

Vitularia dominicana E. H. Vokes, 1977, p. 194, text-fig. 1.

Description.

Four post-nuclear whorls, plus a protoconch of one-and-one-half smooth submerged whorls. Spire greatly flattened. No surface ornamentation visible except seven or eight swollen knobs, which appear around the shoulder. No varices except at the aperture, where a fimbriate surface is developed between the outer surface of the shell and the inner side of the aperture. Surface of the body whorl covered with a pustulose surface, randomly arranged. Aperture ovate, slightly patulate [i.e., patulous]; inner lip smooth, except for a moderately strong anal tooth, well within the posterior fold of the aperture. Inside of outer lip bearing seven large denticles. Anterior canal short, straight, with a broad siphonal fasciole. (Vokes, 1977, p. 194)

Diagnosis.—Low-spined thaidine, terminal varix only, remainder of shell with about seven indistinct knobs at the shoulder of each whorl; surface of shell pustulose. Aperture ovate, inner lip smooth except for a strong anal tooth; outer lip denticulate within. Siphonal canal short, broad, straight; umbilicate.

Holotype.—USNM 247902.

Type locality.—Locality TU 1210, Gurabo Formation; Río Gurabo, east bank, first bluff below the ford on the Los Quemados-Sabaneta road, Dominican Republic (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 5).

Material.—Three specimens, all from the type locality.

Measurements.—USNM 247902 (holotype); height 28.2 mm, diameter 23.5 mm; locality TU 1210.

Remarks.—On the very first day of our collecting on the Río Gurabo, a single specimen of a new species of *Vitularia* was found. In all of the subsequent collections made both by my husband and I and by the NMB team only one additional specimen has been taken. Another incomplete example was discovered by Professor E. Marciano F., formerly of the Museo Nacional de Historia Natural, Santo Domingo, Dominican Republic. All of these specimens came from the type locality (loc. TU 1210) on the Río Gurabo, in what are considered rather deep-water beds. This is in marked contrast to the habitat of the Indo-Pacific cognate species *V. miliaris* (Gmelin, 1791), which is usually found in shallow water under stones, or on reefs.

Comparisons.—In the fossil record of the western Atlantic, there is one other species of *Vitularia*, a high-spined form originally named *V. linguabison* (Vokes, 1967b) but later shown (Vokes, 1986) to be a synonym of the Recent eastern Pacific species *V. salebroso* (King and Broderip, 1832). The latter species occurs in beds of Pliocene age in Florida and Mexico (as *V. linguabison*), Ecuador (as *V. ecuadorana* Marks, 1951), in the Pleistocene of Panama, and in the Recent fauna of the eastern Pacific from Mexico to Ecuador. This widespread distribution may be a reflection of the multi-spiral three-and-one-half whorl protoconch, which is one of the chief differences between that species and *V. dominicana*, which has a paucispiral one-and-one-half whorl protoconch. The only flaw in this theory is the fact that the Recent Indo-Pacific species *V. miliaris*, to which the Dominican Republic species has the most resemblance, morphologically, also has a paucispiral protoconch but is one of the most widespread of Indo-Pacific species, occurring from Hawaii to Japan and south to Australia and the east coast of Africa.

The protoconchs of *V. dominicana* and *V. miliaris* are identical and, given the innate variability in the genus *Vitularia*, one is tempted to suggest that the Dominican species is just another synonym of the much-named *V. miliaris*. However, the American form does have one consistent difference and that is a strong anal ridge at the posterior portion of the aperture. Nevertheless, this is another of the Indo-Pacific elements that mark the Dominican Republic fauna.

Occurrence.—Gurabo Formation: Río Gurabo (TU 1210).

Distribution.—Gurabo Formation, Dominican Republic.

APPENDIX

The following are TU fossil localities not in the Dominican Republic, which are cited in this paper:

TU 458.—Chipola Formation, east bank of Chipola River, above Farley Creek (SW ¼ sect. 20, T. 1 N., R. 9 W.), Calhoun Co., Florida.

TU 546.—Chipola Formation, Ten Mile Creek, about 1¼ miles west of Chipola River (NE ¼ sect. 12, T. 1 N., R. 10 W.), Calhoun Co., Florida (= loc. USGS 2212, "one mile west of Bailey's Ferry").

TU 547.—Chipola Formation, west bank of Chipola River, about 2000 ft above Four Mile Creek (SW ¼ sect. 29, T. 1 N., R. 9 W.), Calhoun Co., Florida.

TU 589.—Río Banano Formation, Río Banano, north bank, about 0.6 to 0.8 km above the railroad bridge at La Bomba, Limón Province, Costa Rica.

TU 635.—Unnamed formation, roadcut on Mexico Highway 185, 1.4 miles south of bridge over Río Jaltepec, Veracruz, Mexico.

TU 638.—Agueguexquite Formation, roadcut and quarry on Mexico Highway 180, 14 mi east of junction with side road into Coatzacoalcos, Veracruz, Mexico.

TU 705.—Bowden Formation, type locality, Bowden, east of Port Morant, Parish of St. Thomas, Jamaica.

TU 727.—Bermont Formation, borrow pits 2.2 mi east of U. S. Highway 27, 15 mi south of South Bay, Palm Beach Co., Florida.

TU 820.—Chipola Formation, Farley Creek, at bridge of Florida Highway 275 (SW ¼ sect. 21, T. 1 N., R. 9 W.), Calhoun Co., Florida.

TU 953.—Moín Formation, type locality, Moín Hill, railroad cut and adjacent ditches on road to Sandoval, 4.5 km west of Puerto Limón, Costa Rica.

TU 954.—Moín Formation, hill cut immediately behind Standard Fruit Co. box factory, just west of cemetery at Pueblo Nuevo, about 2 km west of Puerto Limón, Costa Rica.

TU 956.—Moín Formation, hill slope behind Baptist Church on road between Puerto Limón and Pueblo Nuevo, Costa Rica.

TU 964.—Gatun Formation, road from Cativá to Samba Bonita Island, about ¾ mi (airline) north of Cativá, Prov. of Colón, Panama.

TU 965.—Gatun Formation, river bank just below spillway at Gatun Lock, Panama Canal, to the southwest of the lock (= Woodring loc. Nos. 160, 160a), Canal Zone.

TU 967.—Río Banano Formation, Río Banano, south bank, just above railroad bridge at La Bomba, Limón Province, Costa Rica.

TU 1046.—Agueguexquite Formation, roadcuts on both sides of Mexico Highway 180, 7.5 mi east of junction with side road into Coatzacoalcos, Veracruz, Mexico.

TU 1175.—Pinecrest and Calosahatchee formations (mixed), spoil banks along canal south of Florida Highway 858, 2 mi east of junction with Florida Highway 846 (SE ¼ sect. 24, T. 48 S., R. 27 E.), east of Naples and south of Immokalee, Collier Co., Florida.

TU 1239.—Moín Formation, hill cut behind Standard Fruit Co. box factory at Pueblo Nuevo, same as locality TU 954 but stratigraphically about 50 ft higher (*above* coral horizon), Puerto Limón, Costa Rica.

TU 1240.—Moín Formation, Barrio Los Corales, top of hill at end of road that passes Standard Fruit Co. box factory (see loc. TU 954), 1.8 km north of main highway at Pueblo Nuevo, which is 2 km west of Puerto Limón, Costa Rica.

TU 1268.—Río Banano Formation, roadcut on dirt road that parallels Río Banano on north side, 1 km west of La Bomba, Limón Province, Costa Rica.

TU 1269.—Cantaure Formation, series of arroyos about 500 m south of "Casa Cantaure" [which is literally one house and which is about 400 m south of older, now abandoned, house that was the "Casa Cantaure" of Jung, 1965, and others], 14 km (by road) west of Pueblo Nuevo, Paraguaná Peninsula, Venezuela.

TU 1307.—Moín Formation, hill top approximately halfway between Puerto Limón and Barrio Los Corales and about 0.5 km north of highway at Pueblo Nuevo, Costa Rica.

TU 1321.—Concepción Inferior Formation, K 70 on Trans-Isthmus railroad south of Coatzacoalcos; K 70 is 5 km north of Almagres, Veracruz, Mexico.

TU 1432.—Gatun Formation, north side Boyd-Roosevelt Highway, clearing behind Residential Martin Luther King (formerly Palo Quemado), approximately 1.5 km east of junction of road to "Refinería Panamá, S. A.," at Cativá, Prov. of Colón, Panama.

The following are Tulane University Recent collecting localities, which are cited in this paper:

TU R-166.—Barra de Navidad, Jalisco, Mexico; rocky point across inlet from main sandbar.

TU R-424.—Playa Palmyra, just east of Bani, or about 27 km west of San Cristobal, Dominican Republic.

NEOGENE PALEONTOLOGY IN THE NORTHERN DOMINICAN REPUBLIC

9. The Family Cardiidae (Mollusca: Bivalvia)

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ABSTRACT

The richly fossiliferous Neogene formations of the Yaque Group of the Dominican Republic include the following units: Baitoa Formation (early Miocene), Cercado and Gurabo formations (latest Miocene-early Pliocene), and the Mao Formation (mid-Pliocene), which is divisible into two members, the Mao Adentro Limestone and the Mao Clay. The family Cardiidae in these units consists of 24 species, referable to five subfamilies, in 12 genera or subgenera. Thirteen of these 24 species are confined to the Dominican fauna, insofar as presently known, and the identification of one additional form that has been reported from other areas is herein considered questionable.

Four of the 24 species are new, described herein. Three are from the Cercado Formation: *Trachycardium flexicostatum*, *Trigoniocardia marcanoi*, and *T. leptopleura*; and one from an unnamed formation: *Trigoniocardia clinocostata*. One new name is given as a replacement for a preoccupied name: *Laevicardium venustulum*. Four of the species are present in the Recent Caribbean fauna, but four others are referred to genera that today are confined to the eastern Pacific.

As most species of Cardiidae are relatively shallow-water forms, it is not surprising to find that the majority of the fossil specimens in the present collections come from localities in the shallow-water Cercado Formation and from the shallower-water facies of the Gurabo Formation. Only four species are represented in the Mao Formation, which is predominately a deep-water formation, and two of these were collected from shallow-water beds only tentatively placed in the Mao Adentro Limestone Member.

RESUMEN

Las ricas formaciones fosilíferas del Neógeno del Grupo Yaque de la República Dominicana incluyen las siguientes unidades: Formación Baitoa (Mioceno temprano), formaciones Cercado y Gurabo (Mioceno último y Plioceno temprano) y la Formación Mao (Plioceno medio), que se divide en dos miembros: Caliza Mao Adentro y Arcillosa Mao. La familia Cardiidae de estas unidades consiste en 24 especies, referibles a cinco subfamilias y 12 géneros o subgéneros. Trece de estas 24 especies están restringidas a la fauna dominicana, tal como se conoce hoy día, y la identificación de una forma adicional que han sido reportada en otras áreas se considera aquí cuestionable.

Cuatro de las 24 especies se describen como nuevas; tres de la Formación Cercado: *Trachycardium flexicostatum*; *Trigoniocardia marcanoi*, y *T. leptopleura*; y una de una formación sin nombre: *Trigoniocardia clinocostata*. Se otorga el nuevo nombre *Laevicardium venustulum* como reemplazo a un nombre preocupado. Cuatro de las especies están presentes en la fauna del Caribe Reciente pero cuatro otras se refieren a géneros que hoy están restringidos al Pacífico oriental.

La mayoría de las especies de Cardiidae son formas de agua relativamente somera y, por lo tanto, no hay que sorprenderse en encontrar que la mayoría de los especímenes fósiles en las colecciones de hoy día provengan de localidades en la Formación Cercado y las facies de agua somera de la Formación Gurabo. Solamente cuatro especies están representadas en la Formación Mao que es predominantemente una formación de aguas hondas, y dos de estas fueron coleccionadas en lechos de agua somera sólo tentativamente colocados en el miembro Caliza Mao Adentro.

INTRODUCTION

The fossil faunas of the Cibao Valley (Río Yaque del Norte area) of the Dominican Republic (Text-fig. 1) include 24 species or subspecies of the family Cardiidae, here referred to five subfamilies and 12 genera and/or subgenera. The early Miocene Baitoa Formation contains three species, two of which are confined to that horizon. The overlying late Miocene, shallow-water Cercado Formation has yielded 14 species and subspecies, six of which are confined to it. In the adjacent, somewhat younger, latest Miocene/early Pliocene Gurabo Formation there are 16 cardiid species, of which eight in the present collections are represented

only from this unit. Four species are present in the fauna of the mid-Pliocene Mao Formation, two of which are tentatively referred to the Mao Adentro Limestone Member. Both of these are also present in the Recent faunas of the Caribbean area, as are two species of *Laevicardium* Swainson, 1840, present in the Gurabo fauna, only one of which occurs in the collections from the Mao Formation.

Twelve of the 24 species here cited from the Dominican fauna were first described from this area. They are (in alphabetical order): *Cardium aminense* Dall, 1900; *C. haitense* variety *cercadicum* Maury, 1917; *C. cinderellae* Maury, 1917; *C. dominicanum* Dall, 1900;

C. dominicense Gabb, 1873; *C. haitense* Sowerby, 1850; *C. lingua-tigris* Maury, 1917; *C. sambiacum* Maury, 1917; *C. tintinnabularum* Maury, 1917; *C. venustum* Gabb, 1873 [non Dunker, 1861, herein renamed *Laevicardium venustum*]; *Protocardia gurabica* Maury, 1917; and *P. islahispaniolae* Maury, 1917.

The four new species described herein result in two-thirds of the known cardiid fauna having been first recognized from Dominican localities; although three species have subsequently been discovered to occur in correlative beds in other parts of the western Atlantic. Of the eight remaining species, four were described from the Recent fauna of the Caribbean Sea, and four are from other fossil horizons. Two of the latter were described from the late Miocene of Trinidad [*Cardium maturensis* Dall, 1900, and *Trigoniocardia melajoensis* Jung, 1969] and two from the basal Pleistocene! Bowden Formation of Jamaica [*C. lingua-leonis* Guppy, 1866a, and *C. bowdenense* Dall, 1900]. Thus, of the total number of 24 species of cardiids, 13 (or just over one-half) remain unique to the Dominican beds.

The first cardiid species to be described from the island of Hispaniola was *Cardium haitense*, named by Sowerby (1850, p. 52, pl. 10, fig. 11 [two views]) from a small collection of fossils sent by T. S. Heneken ["J. S. Heniker" in the publication], a British Army officer, to the Geological Society of London. *Cardium haitense* was one of 59 new species noted in the collection which,

See Lamb and Beard, 1972, p. 32.

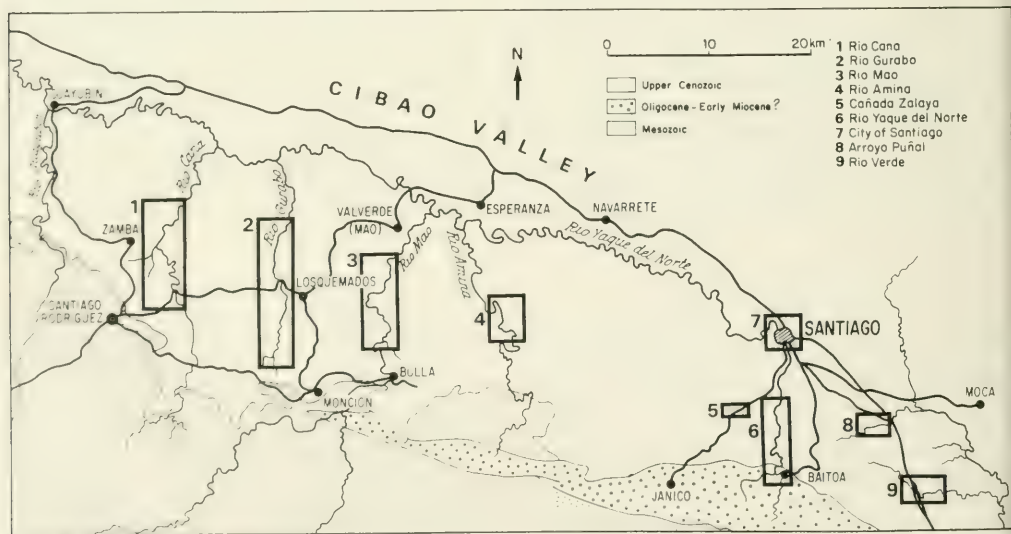
according to Moore (1850, p. 49), in an introductory discussion preceding Sowerby's description, was made by "Heniken" from the area of the "Yaqui" River valley from

rivers [that] have cut narrow channels through the strata, which are thus exposed in perpendicular cliffs often 200 feet high. These cliffs near the bottom consist of bluish sandy shale, whence M. Heniker extracted the greater part of the fossils shortly to be mentioned.

There was no more precise locality information.

Twenty-three years later, Gabb (1873) named three new species: *Cardium* (*Trachycardium*) *dominicense* (p. 250), *Cardium* (*Serripes*) *bullae* (p. 251; here referred to the lucinid genus *Anodontia*), and *Cardium* (*Laevicardium*) *venustum* (p. 251; non *Cardium venustum* Dunker, 1861, here renamed *Laevicardium venustum*). Unfortunately, Gabb, who believed that all of his fossils came from the same "Miocene formation", did not cite any locality data nor did he illustrate any of his species. This latter problem was largely solved by Pilsbry (1922), who redescribed most of the Gabb species and illustrated their types.

It was 43 years after the Gabb work that Carlotta Maury, having secured financing from various sources, was able to undertake a new study of the Río Yaque del Norte area. The years between her expedition and that of Gabb were marked by much political unrest in the Hispaniola area, and disturbance was still enough of a factor in 1916 that, according to Axel Olsson (oral commun., 1958), Miss Maury was persuaded to remain



Text-figure 1 — Locality map for the sections measured and described by Saunders, Jung, and Biju-Duval (1986). The TU collections were made in these same areas and also in intervening areas. See Appendix 4 of that work for a complete description of all Tulane localities.

in the port of Monte Cristi while he and Karl Schmidt proceeded into the Cibao Valley to collect the fossil fauna. They succeeded in getting part way, including the valleys of the Río Cana, Río Gurabo, and Río Mao, before another revolt broke out and they had to flee back to the ship. The result of their work, published by Maury (1917), included descriptions of more than 300 species of fossil mollusks with locality data; included were six new species and one new "variety" of cardiids.

The fauna of the entire Dominican Republic, including the more eastern areas of the Cibao Valley not reached by the Maury Expedition, was collected in 1919 by a geological party headed by T. Wayland Vaughan, whose report including extensive faunal lists was published in 1921 as "Mémorial 1 of the Geological Survey, Dominican Republic". The presence of many new species was indicated, but none of them was described.

In the 1960's my wife, Emily H. Vokes, and I secured a grant from the National Science Foundation designed to enable us to continue the study begun by the Maury group. But before we were able to begin, yet another revolution broke out and the study had to be aborted. Then, early in 1976 we happened to see an advertisement in the *New Yorker* magazine saying: "Come to the Dominican Republic, the best-kept secret in the Caribbean." We were on the way almost immediately, spending thereafter part of each summer (and a few "dry-season" Christmas breaks) from 1976 through 1983 collecting fossils and studying the stratigraphy of the Cibao Valley. In late 1979 we learned that the group from the Naturhistorisches Museum, Basel, Switzerland, had begun a similar study in 1978. Subsequently, it was agreed to pool our resources and to send our material to specialists in the various groups of invertebrates for study. The present report is one result of this combination of collections. Localities of collection naturally overlap, but are cited with initials indicating original collectors: TU = Tulane University, and NMB = Naturhistorisches Museum, Basel. The Tulane localities are shown in Saunders, Jung, and Biju-Duval (1986): Río Gurabo in text-figure 5; Río Cana in text-figure 15; Río Yaque del Norte in text-figure 21; Río Mao in text-figure 29; Río Amina in text-figure 34; Cañada de Zamba in text-figure 36; Arroyo Puñal in text-figure 37; and Río Verde in text-figure 38.

ACKNOWLEDGMENTS

The relatively long period of time spent in the Cibao Valley has resulted in our being indebted to many individuals for aid in the field. Particularly helpful were the many children who live in the settlement of Gurabo Adentro, especially those of Francisco Antonio Torre

and Celesta Diaz who, as E. H. Vokes says (1989, p. 8) "have grown up collecting fossils with us." Special mention must also be made of Vinicio Jaques, from the same area, who collected with us over a much wider area, and whose strong back helped carry the collections back to our transport facilities. Prof. Eugenio de Jesus Marciano F., for some time Director of the Museo Nacional de Historia Natural, Santo Domingo, and an ardent student of Dominican molluscan fossils gave us a number of important and valuable specimens from his personal collection and, in addition, provided useful information on previously unreported collecting areas.

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BIOSTRATIGRAPHY AND PALEOECOLOGY

Saunders, Jung, and Biju-Duval (1986) have given a general overview of the Dominican beds, and E. H. Vokes (1989) has provided a more detailed, historical survey of the growth of our personal knowledge of the stratigraphic sequence.

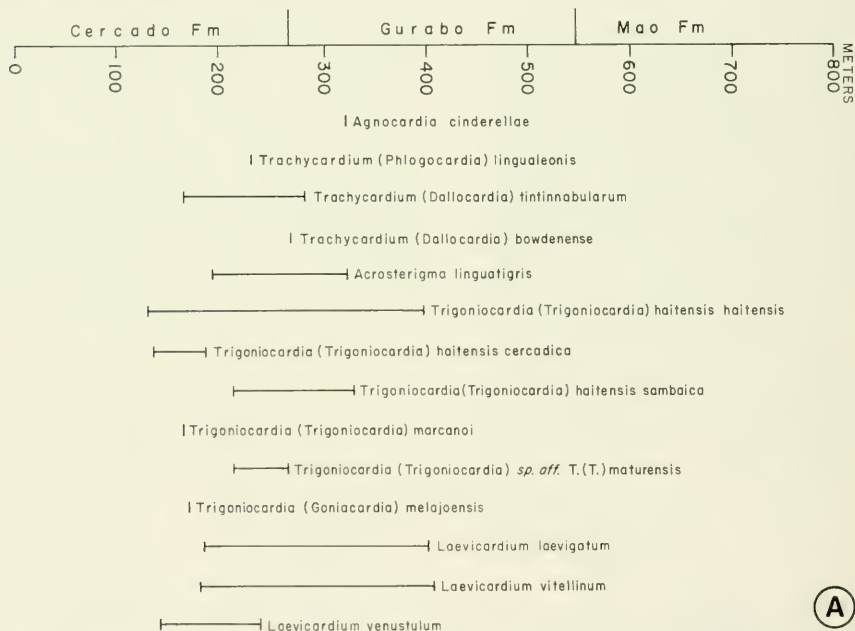
The Baitoa Formation, late early Miocene or early middle Miocene, is present only in a relatively small area of outcrop southeast of Santiago, where it rests

with angular unconformity upon the Oligocene Tabera Formation. The basal portion of the Baitoa Formation, as exposed in the cliffs adjacent to the town of Baitoa, is conglomeratic with well-rounded boulders and pebbles encased in coarse sand matrix (E. H. Vokes, 1979, text-fig. 1). The higher strata, as exposed along the course of Arroyo Hondo, which enters the valley of the Río Yaque del Norte downstream from the town of Baitoa, consists mainly of medium-grained sandstones. All but four of the more than 100 valves of *Trigoniocardia aminensis* (Dall, 1900) came from the Arroyo Hondo outcrops, as did most of the specimens of the other two cardiid species present in that fauna: *Trachycardium (Dallocardia) dominicense* (Gabb, 1873) and *T. (D.) tintinnabularum* (Maury, 1917).

The Bulla Conglomerate, and the Cercado and Gurabo formations, although each mappable units and

hence true formations, represent depositional facies and grade laterally into each other, from the onshore Bulla Conglomerate, through the shallow-water Cercado into the deeper, offshore Gurabo Formation. The Bulla Conglomerate, like the Baitoa Formation, rests unconformably on the Tabera Formation, a fact that, combined with the conglomeratic nature of the strata, has led many previous students to consider them stratigraphic equivalents. However, Vaughan, Cooke, and Condit found a small fauna in the Bulla that is clearly of Cercado age (see Vaughan *et al.*, 1921, pp. 115–124, loc. USGS 8529). No cardiid species were reported and none are in the collections presently available.

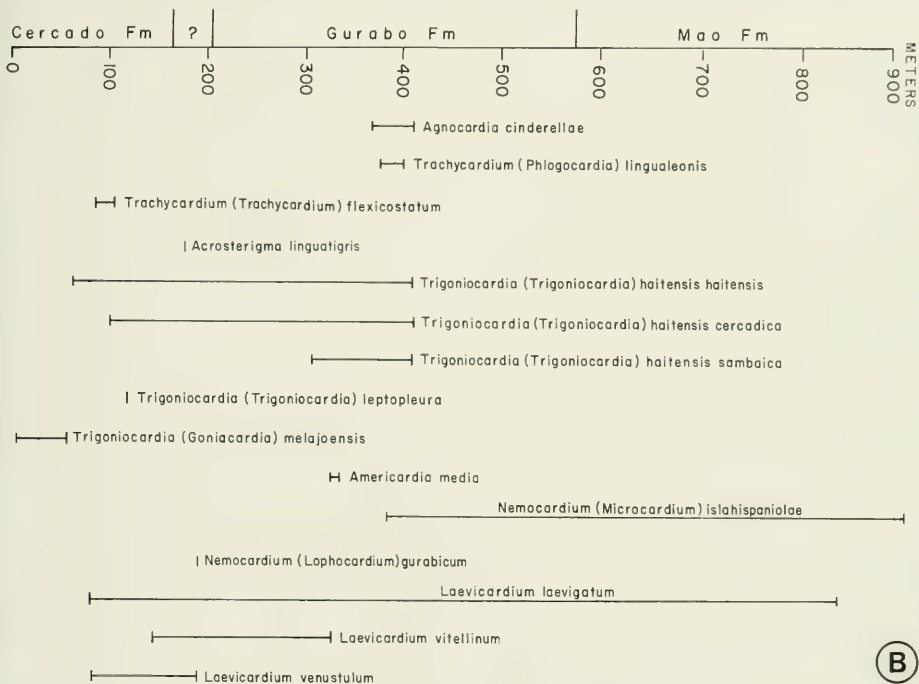
The relative depths of deposition of the Cercado and Gurabo formations are well-illustrated by the data shown in Text-figures 2 and 3, where the distribution of the cardiid species in collecting localities listed in



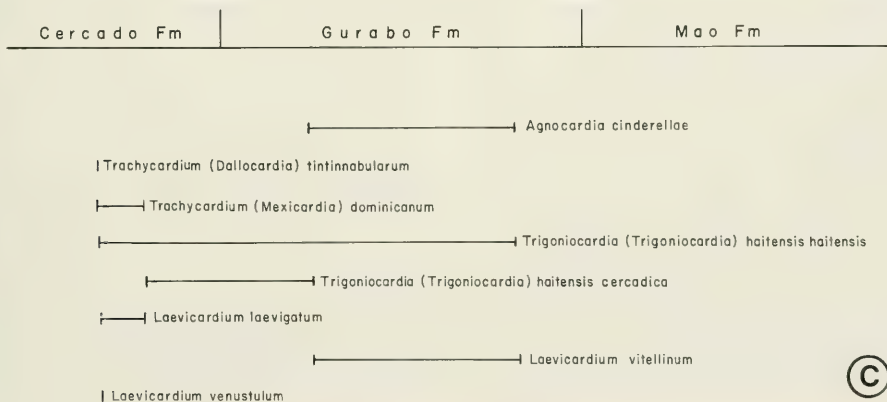
Text-figure 2.—Distribution of cardiid species on the Río Cana (A), Río Gurabo (B), and Río Mao (C), plotted by relative position of the outcrop localities from which they were collected, as given in the maps and columnar stratigraphic sections of Saunders, Jung, and Biju-Duval (1986): Río Cana, text-figures 15, 16; Río Gurabo, text-figures 4–6; Río Mao, text-figures 29–33. The queried segment between the Gurabo and Cercado formations on the Río Gurabo indicates uncertainty as to the exact position of the contact between the two formations (see E. H. Vokes, 1989, p. 18). Stratigraphic assignments on the Río Mao are a reflection of the collecting localities available (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 29). Hence, the Cercado Formation begins at Bluff 3 of Maury (1917) (= locs. USGS 8525, TU 1294, and associated NMB localities [see Saunders, Jung, and Biju-Duval, text-fig. 33]), and extends as far downriver as locs. USGS 8521–8524 (= locs. TU 1419 [not shown on Saunders, Jung, and Biju-Duval, text-fig. 29] and NMB 16802, 16803). This point is taken as the contact between the Cercado Formation and the Gurabo Formation, which then extends downriver past Bluff 1 of Maury (= locs. USGS 8519, 8520, TU 1293, NMB 16910, 17175) to the last bluff before Mao Adentro/Paso Jiménez (= locs. USGS 8528, TU 1292, NMB 16801). The contact between the Gurabo and the Mao formations is somewhere in the vicinity of Paso Jiménez, as the first bluff below Paso Jiménez is the type locality of the Mao Adentro Member of the Mao Formation (= locs. USGS 8523, 8533, TU 1336).

progressive downstream sequence (up section) in the Río Cana, Río Gurabo and Río Mao is shown for comparison with the available data on the depth ranges of analogous Recent species in American waters. Species referable to *Agnocardia* Stewart, 1930, and *Goniocardia* Woodring, 1982, are included in the diagrams to show their stratigraphic distribution, although both groups are now extinct and so not included in the depth

distribution chart. No species whose Atlantic analogues show maximum depth ranges *less* than 45 m occur in the fauna of the Gurabo Formation. The only two species that occur in the fauna of the deep-water Mao Formation are *Nemocardium* (*Microcardium*) *islahispaniolae* (Maury, 1917), whose modern analogue attains depths of 640 m in the western Atlantic waters, and *Laevicardium laevigatum* (Linnaeus, 1758), which



(B)



(C)



Text-figure 3 — Depth-ranges (in m) of Atlantic and Pacific Recent cardiid species or genera that are analogous to Dominican species, given as evidence of increasing depth of deposition of the Cercado, Gurabo, and Mao formations. Information from all available sources, in particular: Atlantic fauna from Clench and Smith, 1944, Abbott, 1974, Rios, 1985; Pacific fauna from Hertlein and Strong, 1947, Olsson, 1961, Keen, 1971.

has been reported from depths as great as 447 m in the western Atlantic fauna.

In the vicinity of the village of López, along the Río Yaque del Norte, just above the Angostura Gorge (see Saunders, Jung, and Biju-Duval, 1986, text-fig. 21), a section is exposed that is unlike either the typical silty Gurabo Formation or the sandy Cercado Formation, the upper part of which Bold (1988, table 4) correlates with these beds. E. H. Vokes (1989, p. 20) has discussed this section in detail and concludes that, because of the differences in facies, it is preferable to refer to these beds only as an "unnamed formation". From this section all 24 of the specimens of *Trigoniocardia clinocostata*, n. sp., were recovered but the species occurs nowhere else, a confirmation of the unusual environmental conditions that prevailed here. The only other cardioid species that occurs in any numbers (250 specimens) in this area is *Americardia guppyi* (Thiele, 1910), which today is commonly found in calcareous environments, such as the Bahama Banks.

Two species of *Americardia*, *A. media* (Linnaeus, 1758) and *A. guppyi* were collected from a road-metal quarry on the south side of the Río Yaque del Norte about 2 km east of Guayubin. This locality is at the northwesternmost end of the Samba Hills and represents a back-reef and/or lagoonal facies, similar to that which occurs today along the east coast of the Yucatan Peninsula, for example. Whether this is to be referred to the Mao Adentro Member of the Mao Formation or not is debatable — it is the source of the material in the Mao Adentro gravity flows. Both species are also present in the collections from the Gurabo Formation, as well as in the Recent Caribbean fauna.

It is clear that other factors, in addition to depth, enter into the distribution of the species. This fact was noted by Jung (1986, p. 9) relative to the distribution of two species of *Strombina* Möhrh, 1852, both of which lived penecontemporaneously during the time of deposition of the lower part of the Cercado Formation. One, *S. gurabensis* (Maury, 1917), is represented by more than 1000 specimens from the Río Gurabo section only, the other, *S. pseudohaitiensis* (Maury, 1917), by more than 1000 specimens only from the Río Mao section and yet the two occurrences are less than 10 km apart. A similar factor is revealed in the cardioid collections: *Trachycardium (Mexicardia) dominicanum* (Dall, 1900) is represented by more than 3000 valves from the basal beds of the Cercado Formation in the Río Mao section; 180 valves of *Trigoniocardia (Goniocardia) melajoensis* Jung, 1969, are to be found in the same relative horizon in the Río Gurabo section, but none are known from the Río Mao.

The stratigraphic distribution of the 24 cardioid species reported herein from the faunas of the Yaque Group

in the northwestern Dominican Republic is given in Table 1.

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

A paleontologic cardioid species, unlike a Recent one, must be based upon preserved hard parts, plus what evidence these may have impressed upon them by body structures, such as the adductors and other muscles, and the nature of the pallial line, with or without a pallial sinus. Most cardioid species are based primarily upon factors of shell shape, variations in hinge structure (of greater importance in generic assignment), presence or absence and, if present, the relative strength of a posteroventral angulation, the relative number and shape of the ribs and interspaces, and the nature of their ornamentation. The array of ribs, spines, knobs, and tubercles that adorn the shells of the family Cardiidae have been the subject of a study by Savazzi (1985), who attempted to ascertain if these features were of some benefit in the burrowing process of the animal. It was his conclusion that the various morphologies "are most likely the result of parallel evolution, since similar morphologies often occur in distantly related groups" (Savazzi, 1985, p. 309), and the different sculptural types "seem to be neutral features of taxonomic value only" (Savazzi, 1985, p. 314).

As Savazzi demonstrates, these ornaments commonly are a basic part of the shell structure and are "growth-conformable" (Savazzi, 1985, fig. 11), but in the subfamily Fraginae, they are a surficial chalky deposit that covers the ribs and interspaces, adding patterns of nodes upon them. This deciduous layer has been recognized in several families of Gastropoda and Bivalvia, and was named the *intritacalx* by D'Attilio and Radwin (1971). When this relatively soft intritacalx is worn or abraded off, the ribs are smooth, and lack any ornament (e.g., Pl. 18, figs. 1, 3).

The striking difference in the nature of the shell ornament in the Fraginae is a result of the fact that the members of the subfamily Fraginae alone among the Cardiidae are not shallow infaunal burrowers. Instead, the Fraginae are surface dwellers, commonly associated with coral reefs. They mimic the life style of the Tridacnidae even to the extent that certain genera possess symbiotic photosynthetic zooxanthellae (Savazzi, 1985, p. 297). In this group, the intritacalx almost certainly functions as a thick periostracum to protect the shell surface.

The heading "Diagnosis" is used only for the description of supraspecific categories, but the term "Description" is used for species-level units, where the term applies to a definition based primarily upon the material available for examination, including non-Do-

Table 1.—Distribution of species of Cardiidae in the Neogene of the northern Dominican Republic.

	Baitoa Formation	Cercado Formation	Gurabo Formation	Mao Formation	Recent
Subfamily Cardiinae					
<i>Agnocardia cinderellae</i> (Maury)	—	—	+	—	—
Subfamily Trachycardiinae					
<i>Trachycardium</i> (<i>Trachycardium</i>) <i>flexicostatum</i> , n. sp.	—	+	—	—	—
<i>Trachycardium</i> (<i>Phlogocardia</i>) <i>lingualeonis</i> (Guppy)	—	+	+	—	—
<i>Trachycardium</i> (<i>Dallocardia</i>) <i>dominicense</i> (Gabb)	+	—	—	—	—
<i>Trachycardium</i> (<i>Dallocardia</i>) <i>tintinnabularum</i> (Maury)	+	+	+	—	—
<i>Trachycardium</i> (<i>Dallocardia</i>) <i>bowdenense</i> (Dall)	—	—	+	—	—
<i>Trachycardium</i> (<i>Mexicardia</i>) <i>dominicanum</i> (Dall)	—	+	—	—	—
<i>Acrosterigma linguatigris</i> (Maury)	—	+	+	—	—
Subfamily Fraginae					
<i>Trigoniocardia</i> (<i>Trigoniocardia</i>) <i>haitensis haitensis</i> (Sowerby)	—	+	+	—	—
<i>Trigoniocardia</i> (<i>Trigoniocardia</i>) <i>haitensis cercadica</i> (Maury)	—	+	+	—	—
<i>Trigoniocardia</i> (<i>Trigoniocardia</i>) <i>haitensis sambaica</i> (Maury)	—	+	+	—	—
<i>Trigoniocardia</i> (<i>Trigoniocardia</i>) <i>marcanoi</i> , n. sp.	—	+	—	—	—
<i>Trigoniocardia</i> (<i>Trigoniocardia</i>) <i>clinocostata</i> , n. sp.	—	—	+	—	—
<i>Trigoniocardia</i> (<i>Trigoniocardia</i>) <i>leptopleura</i> , n. sp.	—	+	—	—	—
<i>Trigoniocardia</i> (<i>Trigoniocardia</i>) sp. aff. <i>T. (T.) maturensis</i> (Dall)	—	+	+	—	—
<i>Trigoniocardia</i> (<i>Trigoniocardia</i>) <i>aminensis</i> (Dall)	+	—	—	—	—
<i>Trigoniocardia</i> (<i>Goniocardia</i>) <i>melajoensis</i> (Jung)	—	+	—	—	—
<i>Americardia media</i> (Linnaeus)	—	—	+	+	+
<i>Americardia guppyi</i> (Thiele)	—	—	+	+	+
Subfamily Protocardiinae					
<i>Nemocardium</i> (<i>Microcardium</i>) <i>islahispaniolae</i> (Maury)	—	—	+	+	—
<i>Nemocardium</i> (<i>Lophocardium</i>) <i>gurabicum</i> (Maury)	—	+	—	—	—
Subfamily Laevicardiinae					
<i>Laevicardium laevigatum</i> (Linnaeus)	—	+	+	+	+
<i>Laevicardium vitellinum</i> (Reeve)	—	+	+	—	+
<i>Laevicardium venustum</i> , new name	—	+	+	—	—
Total number of taxa: 24	3	16	16	4	4

minican Republic specimens. The term "Occurrence" is followed by a list, by number, of those localities within the area under study in which the particular taxonomic group occurs. (For a full description of all localities and their relative stratigraphic position, see Saunders, Jung, and Biju-Duval, 1986, pp. 41–69, and text-figs. 4, 5, 15, 16, 21, 25, 29, and 34.)

The synonymies contain all references to fossil occurrences that I have been able to discover. But for those species that also occur in the Recent fauna of the western Atlantic only references to fossil occurrences are intended to be complete. For more information, the reader is referred to two excellent sources: Clench and Smith (1944) and Weisbord (1964).

The terminology of the synonymies is as straightforward as possible. The only terms that might cause confusion are: "non", referring to a pre-occupying taxon (only in the case of *Cardium venustum*); "NOT", preceding an entry, which refers to an incorrect assignment of the taxon cited; and "not of", following an entry, which indicates a misidentification of the taxon by the author being cited.

The shell measurements are indicated as follows:

height is the vertical distance from umbo to ventral margin; *length* is the greatest distance from anterior to posterior extremities, measured at right angles to the height; *diameter* is the maximum distance between the outer surfaces of the two valves or, if only one valve is measured, the distance between the outer surface and a plane formed by the shell margins.

ABBREVIATIONS FOR REPOSITORY INSTITUTIONS

- ANSP: Academy of Natural Sciences, Philadelphia, PA, U. S. A.
 BMNH: British Museum (Natural History), London, England, U. K.
 NMB: Naturhistorisches Museum Basel, Switzerland. (The letter "G" appearing after "NMB" in catalogue numbers of type and figured specimens stands for Bivalvia.)
 PRI: Paleontological Research Institution, Ithaca, NY, U. S. A.
 TU: Tulane University, Department of Geology, New Orleans, LA, U. S. A.
 USNM: United States National Museum of Natural History, Washington, DC, U. S. A.

SYSTEMATICS

Superfamily CARDIACEA Lamarck, 1809

Family CARDIIDAE Lamarck, 1809

Diagnosis.—

Equivalve, usually tumid, with well developed radial sculpture; posterior slope normally set off from central and anterior slopes by an umbonal ridge or angle or by a change in ribbing pattern; ligament parivincular, external, mostly short; hinge with two conical cardinal teeth, of unequal size in left valve, somewhat fused in right, arrangement of cardinal teeth in many cruciform (*i.e.*, interlocking in the form of a cross); lateral teeth distant from cardinals, normally one anterior and one posterior in left valve, two anterior and one posterior in right valve (wanting in some groups); adductor muscle scars subequal; pallial line entire in most. (Keen, 1980, p. 9)

Subfamily CARDIINAE Lamarck, 1809

Diagnosis.—

Shells tumid to inflated, outline mostly equilateral or nearly so; ribs well developed, symmetrical, characteristically sculptured along the rib midline by a spinose or nodose thread or by a groove; posterior margin usually notched by rib ends; interspaces between ribs often with concentric striae; hinge long, hinge teeth nearly in a straight line (*i.e.*, a line joining lateral teeth would bisect the cardinals or be bent less than 25°); cardinal teeth subequal in size, tending to be twisted in left valve or even to lie horizontally one above the other. (Keen, 1980, p. 9)

Genus AGNOCARDIA Stewart, 1930

Agnocardia Stewart, 1930, pp. 37, 164.

Type species.—*Cardium (Trachycardium) claibornense* Aldrich, 1911, by original designation; upper Claibornian, middle Eocene, Mississippi and Alabama.

Diagnosis.—Valve surface with 40 or more flat-topped radial costae, separated by square-sided interspaces of half or less their width; costal surfaces with spines of inverted V shape, the medial portion of the valve with ribs bearing short and low, closely approximate spines, alternating with ribs marked by more distantly spaced, larger, high, prominent ones.

Remarks.—*Agnocardia*, originally described by Stewart as a subgenus of *Trachycardium* Mörch, 1853, was assigned a position as a subgenus of *Acanthocardia* Gray, 1851 (type species by subsequent designation, Stoliczka, 1870: *Cardium aculeatum* Linnaeus, 1758; see Keen, 1969, p. 585; also Keen, 1980, p. 16). As pointed out by Stewart, the hinge of the Claibornian type species is not known, *Agnocardia* being erected on the basis of "the peculiar ornamentation of the type species and its allies, which consists of numerous, close-set, flat-topped ribs bearing hollow, triangular spines." However, the fact that the numerous, curved, spike-like spines present on the ribs of *Acanthocardia aculeata* (Linnaeus) differ so markedly in shape and structure from the open, chevron-shaped ornament on the ribs of the species referred to *Agnocardia*, together with

the manner in which ribs with larger spines alternate with those having smaller ones, especially on the broad median portion of the valve, led H. E. Vokes (1977, p. 153; 1984, p. 37) to consider *Agnocardia* a separate genus.

Agnocardia cinderellae (Maury)

Plate 13, figures 1–3; Plate 19, figure 9

Cardium (Trachycardium) cinderellae Maury, 1917, pp. 375, 436, pl. (36)62, fig. 4.

Cardium (Trachycardium) cinderellae Maury, Vaughan *et al.*, 1921, p. 145.

Cardium cinderellae Maury, Woodring, 1925, p. 135.

Shell sub-circular in outline, thin, rather fragile; sculpture of forty-four ribs distally channelled, adorned with close-set, conspicuous, spinose vaulted scales; interspaces very narrow, grooved, marked by microscopic, regular transverse striae. . . . A member of the *Cardium muricatum* group. (Maury, 1917, p. 375)

Description.—Shell sub-circular in outline, slightly more produced posteriorly than anteriorly, with a relatively low and moderately inflated umbo; surface ornamented by 44 (in the holotype, *vide* Maury, 1917) to 49 radial costae (mean = 47), each bearing numerous chevron-shaped, scaly spines, those on the median ribs tending to vary in strength and number on alternate ribs, with the mean number per cm of rib-length being eight on a stronger-spined rib, and 12 on the adjoining smaller-spined ones; posteriorly the pattern varies with three to four smaller-spined ribs between the more strongly ornamented ones; spines on the ribs reaching the anterior margin of the valve tend to be of approximately equal strength; costae are almost flat-topped, but have a narrow and shallow median groove that is coincident in position with the apical end of the spines; the narrow, slightly raised margins of the grooves bear the lateral termination of the individual spines, which tend to flare out over the sides of the inter-rib areas; these latter areas, approximately as wide as the adjacent ribs on the median area of the valve, become proportionately narrower anteriorly and posteriorly, and are sharply defined channels with broadly rounded bottoms and almost vertical sides; valve margins denticulated by the ribbing, with the apex of the interdenticle areas terminating at the median depression on the rib surface; hinge with the two cardinal teeth in each valve placed on an oblique line with respect to each other, the more ventral ones being heavier than the dorsal, and those of the right valve having the base of the smaller dorsal one fused to the apex of the large ventral one; anterior and posterior laterals approximately equi-distant from the cardinals; internal medial surface of valve with relatively conspicuous radial markings reflecting the surficial ribbing, but anteriorly and posteriorly these are not as well defined.

Holotype.—PRI 28989.

Type locality.—Gurabo Formation; Zone B, Río Gurabo at Los Quemados (Maury, 1917, p. 375) = locality TU 1211 (here restricted).

Material.—Maury's type plus one complete external cast of a right valve and 12 broken shells from 11 localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
PRI 28989 ¹	25.6	26.0	10.0 ²	TU 1211 (see above)
USNM 416199	36.3 ³	48.2	≈20.5 ²	TU 1211
USNM 416233	29.1 ³	26.0 ³	11.9 ⁴	TU 1225

holotype; ² right valve; ³ incomplete; ⁴ left valve

Remarks.—*Agnocardia cinderellae* (Maury, 1917) appears to be a relatively rare and fragile-shelled species that is confined to the Gurabo Formation. The TU collections contain 12 fragmentary valves from 11 localities; the only specimen sent from the Basel collection is relatively complete, but lacks the posterior portion of the shell. Maury's type is also relatively complete, but as can be seen from the illustration (Pl. 13, fig. 2), has a small fragment lost from the posterior margin and shows a break near the umbonal area, representative of the loss on the umbonal tip and the median (cardinal) part of the hinge structure below it.

Comparisons.—*Agnocardia cinderellae* (Maury) has approximately the same number of radial costae as does the lower Miocene Chipola Formation species *A. acrocome* (Dall, 1900) [p. 1081; see also Dall, 1903, pl. 48, fig. 2], but differs in the shape of the spines that adorn them. Those of *A. acrocome* tend to be relatively narrower and more "pinched in" near their outer ends and distinctly less flared out laterally toward the rib margins where they seldom overhang the lateral margins of the inter-rib area (compare Pl. 19, fig. 9 with pl. 1, fig. 6a of H. E. Vokes, 1977). The Bowden Formation Pleistocene species *A. dissidipictum* (Woodring, 1925) [p. 135, pl. 18, figs. 10, 11] appears to have fewer radial ribs (43, *vide* Woodring) ornamented by spines that, on a worn specimen in the TU collections, appear to have been similar in shape to those on *A. cinderellae*, but which show the basal lateral parts of the spines on the larger radial series only occasionally flaring.

Occurrence.—Gurabo Formation: Río Cana area (TU 1354); Río Gurabo area (TU 1209–1211, 1213, 1214); Río Mao area (TU 1225, 1293, 1334); Santiago area (TU 1227, 1250; NMB 17275).

Distribution.—Known only from the Gurabo Formation, Dominican Republic.

Subfamily TRACHYCARDIINAE Stewart, 1930

Diagnosis.—

Mostly asymmetrical or inequilateral shells; ribs asymmetrical in cross section, well developed throughout shell; spines or other sculp-

ture on ribs usually stronger on posterior edges of ribs; posterior margin notched or even digitate; hinge relatively short, usually less than one-half length of shell, the hinge plate wide in most, cardinal teeth unequal, posterior cardinal in left valve slender. (Keen, 1980, p. 11)

Genus TRACHYCARDIUM Mörch, 1853

Trachycardium Mörch, 1853, p. 34.

Type species.—*Cardium isocardia* Linnaeus, 1758; by subsequent designation, Martens, 1870; Recent, Bermuda, West Indies and northern coast of South and Central America westward to Yucatan Peninsula, Mexico, and southern Texas.

Subgenus TRACHYCARDIUM *sensu stricto*

Diagnosis.—Trachycardiids with ribs ornamented by arched, recurved or denticulated scales or spines, primarily along the posterior side of their dorsal surface; inner shell margins reflecting external ribbing, being well notched, especially on posterior side.

Trachycardium (*Trachycardium*) *flexicostatum*, new species

Plate 13, figures 6–9; Plate 19, figure 2

Etymology of name.—*L. flexus* = bent + *L. costatus* = ribbed.

Description.—Shell elongately subovate, inflated; prosogyrate umbones relatively high and slender; dorsal margin arched, anterior and anteroventral margins broadly and regularly rounded, posteroventral margin more sharply curved into a straight, serrated, posterior margin, which is subangulate at its dorsal extremity; surface ornamented by 22 to 23 radial ribs, those on the medial area of adult valves exhibiting an arched, posterior-trending flexure. The first three or four anterior ribs with a gradually arching anterior slope that rises to a row of tear-drop shaped interconnected nodes, most of which exhibit a weak dimple-like depression on their ventral end; these nodes overhang a narrow, steep posterior slope that marks the anterior side of an interspace area whose posterior side is not delimited from the anterior slope of the succeeding rib; beginning on the next two or three ribs a narrow, steplike break appears approximately one-half way up the anterior slope delimiting a narrow interspace that is approximately one-half the total width of the succeeding rib; coincidentally the posterior sides develop a slope into the next interspace and the ribs become triangular in section; ribs on the anterior half of the median area with a slightly broader anterior than posterior side, while the sides of the ribs of the more posterior part of this area are of essentially equal width; on the posterior slope of the valve the reverse condition develops, the anterior side of the rib becoming narrowed while

the posterior ones widen and are gently arched with interspaces and sides of the costae marked by thin, low, growth lamellae; ornament on ribs variable in strength between specimens, but with the dimple-like depression on the ventral end of the tear-drop shaped nodes present on the most anterior ribs becoming progressively more pronounced until on the ribs on the posterior side of the median area of the valve the nodes resemble hollow scales; on the posterior slope the scales gradually become reduced in size and tend to an oblique trend with the posterior side longer than the anterior. Hinge typical for the genus, but reflecting the relatively narrow profile of the valves as compared with the genotypic species in that the lateral teeth are relatively closer to the cardinals; valve margins strongly denticulate with the projections forming a continuation of the intercostal areas and the interdentate spaces being prolonged up the inner side of the valve under the surficial costae, giving the valve a somewhat plicate section.

Holotype.—USNM 416202.

Type locality.—Locality TU 1358, Cercado Formation; Río Gurabo, west side, at and downstream from the mouth of Arroyo La Cabra, or approximately 6 km (airline) above the ford on the Los Quemados-Sabaneta road, Dominican Republic.

Material.—Thirty right and 20 left valves, plus 12 immature specimens, from seven localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
USNM 416202 ¹	25.7	33.7	12.8 ²	TU 1358
NMB G 16950 ³	27.3	36.0	13.2 ⁴	NMB 15913
USNM 416201 ⁵	25.6	32.1	12.0 ²	TU 1377
USNM 416203 ⁶	28.7	40.2	14.8 ²	TU 1377
PRI 33061 ⁷	24.1	30.7	11.2 ⁴	TU 1377

¹ holotype; ² right valve; ³ paratype A; ⁴ left valve; ⁵ paratype B; ⁶ paratype C; ⁷ unfigured paratype

Remarks.—All right and left valves show the flexure of the ribs on the posterior half of the median area of the shell, although the amount of such flexure varies and, indeed, seems to be somewhat more pronounced on those specimens from the stratigraphically higher localities (e.g., locs. TU 1358 vs. TU 1377; NMB 15912 vs. NMB 15915).

Comparisons.—The holotype (PRI 21254) of *Cardium* (*Trachycardium*) *costaricanum* Olsson, 1922 (p. 226, pl. 27, fig. 3) [= *Trachycardium dominicanum costaricanum* (Olsson, 1922), *vide* Woodring, 1982, p. 641, pl. 116, figs. 29, 30] shows a similar weak flexure of the posterior costae on the median area. This species has 24 ribs that are subtriangular in section on the anterior and median portion of the valve with the apex of the ridge being toward the posterior side, and, on the posterior slope, with the apex on the anterior side.

Costae on the anterior segment have low rounded nodules on the posterior side of the crest that become arched nodes on the apical portion of the medial and first of the posterior costae. The shape and surficial ornament of the ribs is thus unlike that present on the Dominican species.

Trachycardium (*Mexicardia*) *dominicanum* (Dall, 1900), abundant in the basal beds of the Cercado Formation, is a somewhat smaller form with more numerous radial ribs that are marked with a different and less prominent type of surficial ornamentation (see Pl. 14, figs. 8–10).

Occurrence.—Cercado Formation: Río Gurabo (NMB 15912, 15913, 15915; TU 1358, 1376, 1377).

Distribution.—Known only from outcrops in the upper part of the Cercado Formation along the valley of the Río Gurabo, in the vicinity of the mouth of Arroyo La Cabra.

Subgenus PHLOGOCARDIA Stewart, 1930

Phlogocardia Stewart, 1930, p. 263.

Type species.—*Cardium belcheri* Broderip and Sowerby, 1829, by original designation; Recent, Cedros Island and Gulf of California, Mexico, south to Panama (Keen, 1971, p. 155).

Diagnosis.—*Trachycardiids* with rib ornament of node-like spines on anterior costae, and with an elongately dentated ribbonlike series of spines projecting along the posterior half of the median to posterior costae.

Trachycardium (*Phlogocardia*) *lingualeonis* (Guppy)

Plate 13, figures 4–5; Plate 19, figure 8

Cardium lingua-leonis Guppy, 1866a, p. 293, pl. 18, fig. 7; Maury, 1917, p. 374.

Cardium (*Trachycardium*) *sub-elongatum* Sowerby, Gabb, 1873, p. 250 [not of Sowerby, 1841b = *Trachycardium magnum* (Linnaeus, 1758); Gabb erroneously placed *C. lingua-leonis* Guppy in synonymy].

Cardium lingualeonis Guppy, Guppy, 1876, p. 531.

Cardium (*Trachycardium*) *lingualeonis* Guppy, Woodring, 1925, p. 136, pl. 18, figs. 12, 13; Anderson, 1929, p. 165.

Trachycardium lingualeonis (Guppy), Pflug, 1961, p. 82, pl. 25, figs. 1–9.

Shell elongate, subquadrate; valves deep, ornamented with numerous (32) nodosely muricate ribs, which are lower and more distant toward the anterior and posterior margins; margins coarsely crenulate, the posterior one strongly serrate; hinge with three large and stout teeth. (Guppy, 1866a, p. 293)

Description.—Shell elongately subovate, inflated; umbones relatively high and slender in proportion to rest of valve, slightly prosogyrate; ornamentation of 31 to 33 radial ribs, the four or five anterior ones separated by channeled interspaces approximately as wide, bearing median to slightly anteriorly-situated,

disconnected, inflated nodules; on the next six to eight costae the nodes, which occur along the posterior sides of the costae and tend to overhang the interspaces, becoming progressively more obliquely trending, medially swollen, and bead-like with attenuated united extremities producing an effect suggestive of a spirally twisted ribbon. On the median part of the valve, the nodes have evolved into an undulating, ribbonlike flange along the posterior side of the rib that is separated from the anterior portion by a narrow groove; in this region the interspaces are narrow and deeply channeled; posteriorly the smooth anterior segment of the ribs becoming progressively weaker and lower to form relatively broad interspaces between the posterior ribs, on which the beads become wider and transversely swollen; the narrow groove that separates the frilled area from the anterior segment of the medial ribs persists; on the strongly serrate posterior slope of the valve the notches between the tooth-like projections extend up into the area of this groove rather than into the inter-rib areas.

Holotype.—BMNH 64090 (figured by Pflug, 1961, pl. 25, figs. 1, 5).

Type locality.—"Miocene" [= Bowden Formation, basal Pleistocene], Jamaica; = locality TU 705 (here restricted).

Material.—Four left and three right valves plus fragments, from eight localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
BMNH 64090 ¹	35 ²	47 ²	20 ^{2,3}	TU 705 (see above)
NMB G 16949	24.7	31.2	12.2 ³	NMB 16838
USNM 416200	30.2	41.4	18.4 ⁴	TU 1205
PRI 33062	26.9	35.5	14.4 ³	TU 1210

holotype; ² *vide* Pflug, 1961, pl. 25; ³ left valve; ⁴ right valve

Remarks.—In general, the trend of the variation in the ornamentation surmounting the radial ribs is constant in the 12 Dominican specimens available for examination. The only striking variation occurs in the specimen here figured (Pl. 13, fig. 5a), on which the thirteenth rib from the posterior end bears twisted nodes on both the anterior and posterior sides of the median groove.

Comparisons.—*Trachycardium lingualeonis* is certainly closely related to *T. plectopleura* (Gardner, 1926) [p. 134, pl. 22, figs. 10, 11] from the middle Miocene Shoal River Formation of Florida and to the Pliocene Gatun Formation species *T. striatum* (Brown and Pilsbry², 1911) [p. 366, pl. 26, fig. 11]. Both of these species show a similar trend in the variation of the rib

ornamentation, although with minor differences. The ribs on the posterior area of *T. plectopleura*, for example, have nodes that have more or less the appearance of inflated scales projecting on both sides, over the inter-rib area as well as the median central groove; those on *T. striatum* are ornamented by inflated, disconnected nodules similar to those on the anterior area of *T. lingualeonis*. The ornamentation on the ribs of both of these species also tends to be somewhat more strongly developed than that on the present form, in which the valve is also relatively more narrow in proportion to its height than are those of either of the other two species.

Occurrence.—Cercado Formation: Río Cana (NMB 16835, 16838). Gurabo Formation: Río Gurabo (TU 1210, 1212, 1213); Santiago area (TU 1205; "K-14" [now Kilometer 17], Santiago de los Caballeros—San Jose de las Matas road, Pflug, 1961, p. 3 [= loc. TU 1206]). Unnamed formation: López area (TU 1444, 1445).

Distribution.—Upper Cercado and Gurabo formations, and an unnamed correlative formation on the Río Yaque del Norte, Dominican Republic. Tubará Group, Colombia, Pliocene; Bowden Formation, Jamaica, Pleistocene. Dall's (1900, p. 1084) listing of this species from the "Chipola horizon on Shoal River, Walton County, Florida" has been shown by Gardner (1926, p. 134) to have been based upon an "imperfect fragment" of *Cardium* (*Trachycardium*) *plectopleura* Gardner (1926, p. 134, pl. 22, figs. 10, 11).

Subgenus DALLOCARDIA Stewart, 1930

Dallocardia Stewart, 1930, p. 264.

Type species.—*Cardium quadragenarium* [*sic* = *quadragenarium*] Conrad, 1837, by original designation; Recent, Santa Barbara, California to Todos Santos Bay, Baja California; Miocene–Pleistocene, central and southern California.

Diagnosis.—*Trachycardiids* with ornament of separated spinelike nodes on the posterior half of costal surface, with those on the median area of the valve tending to show a diagonal trend.

Trachycardium (*Dallocardia*) *dominicense* (Gabb)

Plate 14, figures 1–3

Cardium (*Trachycardium*) *dominicense* Gabb, 1873, p. 250; Dall, 1900, p. 1082; Pilsbry, 1922, p. 421, pl. 25, figs. 8, 9; Woodring, 1925, p. 139; Maury, 1925b, p. 282.

Cardium inconspicuum Guppy, Guppy, 1876, p. 531 (not of Guppy, 1866a).

NOT *Cardium* (*Trachycardium*) *dominicense* Gabb, Gabb, 1881a, p. 344; Brown and Pilsbry, 1911, p. 367; Olsson, 1922, p. 397, pl. 27(30), fig. 2; Anderson, 1929, p. 164.

NOT *Trachycardium* (*Trachycardium*) *dominicense* (Gabb), Olsson, 1964, p. 53, pl. 6, figs. 1, 1a.

Erroneously cited as "*Cardium striatum* Olsson" by Pflug (1961, p. 82, with reference to *Bulletins of American Paleontology*, vol. 9, No. 39, p. 225, pl. 27, figs. 4, 5).

NOT *Trachycardium (Dallocardia) dominicense dominicense* (Gabb).
Woodring, 1982, p. 638, pl. 114, figs. 10, 11, 14.

Shell elongate, cordiform, convex, thin; umbones prominent; surface ornamented by nearly 60 small sub-squamoso ribs, the lateral ones bearing minute tubercles; edges serrate. (Gabb, 1873, p. 250)

Description.—Shell broadly subovate, subequilateral, with posterior side apparently slightly longer than anterior [there are no complete specimens in the collections]; umbones full, moderately high; valve ornamented by numerous radial ribs (52 to 58 on present specimens), separated by narrow, linear interspaces; the 13 to 16 anterior ribs roundly subtriangular in outline with small, chevron-shaped, scale-like spines along the crests; the spines gradually becoming submicroscopic in size and tending to move toward the posterior side of the ribs that, coincidentally, become broadly arcuate in profile; on the anterior ribs of the posterior slope a groove appears immediately in front of the row of spines; this groove increases in depth until the groove becomes, in effect, the inter-rib area and forms the terminations of the sharp grooves between the serrations formed by the marginal spines; the ornamentation of this posterior area now consisting of the enlarged, formerly posterior portion of the rib, which has become the anterior side of the serrated marginal projection and is marked by the truncated posteroventrally sloping nodes; the posterior side of the projection is formed by the termination of a narrow, smooth-topped area, the former posterior side of the rib, that is now separated from the anterior part by a shallow, round-bottomed area, the former inter-rib area; anterior and ventral margins weakly serrated by the ribbing, the posterior one strongly so.

Holotype.—ANSP 2764.

Type locality.—Locality TU 1364 (here restricted), Baitoa Formation; Boca de los Ríos, below waterfall in Arroyo Hondo, which enters the Río Yaque del Norte from the east, just below the confluence of the Río Yaque and the Río Bao, downstream from Baitoa, Dominican Republic.

Material.—Four left and four right valves, plus one paired valve specimen (all incomplete) from three localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
ANSP 2764 ¹	38 ²	≈44 ²	15 ²	TU 1364 (see above)
USNM 416204	38.0 ³	42.5 ³	38.9 ⁴	TU 1364
USNM 416205	45.6 ³	52.6 ³	≈24.7 ⁴	TU 1364
USNM 416206	35.1	33.7 ³	13.7 ⁵	TU 1363

¹ holotype; ² Pilsbry, 1922, p. 421; ³ incomplete; ⁴ paired valves; ⁵ left valve; ⁶ right valve

Remarks.—Five adult specimens and two fragments are in the collections from the Baitoa Formation, where it outcrops in the Arroyo Hondo above and below a

waterfall that is but a short distance above the mouth of the Arroyo at Boca de los Ríos. In addition, one adult and one immature form are in collections from a roadcut on the old Santiago-Baitoa road one km north of Baitoa (loc. TU 1253). None of these specimens is complete: most lack the ventral and, usually, at least part of the posterior margin. As far as I am aware, the only relatively complete posterior margin is that of the holotype (see Pilsbry, 1922, pl. 25, figs. 8, 9).

Comparisons.—The specimens from Panama identified by Woodring (1982, p. 638) as representing the present species appear to be referable to a different lineage. These specimens from the early Miocene La Boca Formation, which is essentially the same age as the Baitoa, identified by Woodring (1982, p. 638, pl. 99, figs. 2, 3) as "*Trachycardium (Dallocardia) dominicense dominicense* (Gabb), small form" differ from the present species in having fewer ribs, "36 to 49, (generally more than 40)" as compared to the 54 of Gabb's type (Pilsbry, 1922, p. 421) and the 52 to 58 on the present specimens; the preservation of the La Boca material does not permit comparison of the surficial ornament on the ribbing.

The specimens from the middle part of the Gatun Formation, designated by Woodring (1982, pl. 114, figs. 10, 11, 14) as *Trachycardium (Dallocardia) dominicense dominicense* (Gabb), agree more closely in rib count with those from the Dominican Republic, having "49 to 56, generally some 50" ribs; nine Gatun specimens in the TU collections (locs. TU 958, 1430) average 52 ribs. Examination of these latter specimens, however, reveals an entirely different rib shape with a different surficial ornament also. The ribs, particularly those on the median portion of the valves, have vertical sides that drop down into a narrow, trench-like inter-rib area; the upper portion of the ribs, above the vertical section, rises angularly to form a triangular crest marked by a narrow median riblet that is crossed by small transverse nodes, which project beyond its edges. Furthermore, the "diagonally elongate prickles on posterior limb of divided ribs on posterior slope" (Woodring, 1982, p. 639) tend to have their extremities become connected to form a twisted ribbonlike ornament similar to that noted on *T. (Phlogocardia) lingualeonis* (Guppy, 1866a), and the Baitoa specimens show no trace of the "minute prickles or swellings on extreme anterior ribs and on ventral part of adjoining ribs" described by Woodring. Thus, although the Dominican and Gatun specimens agree in general size, shape, and number of costae, they differ entirely in the details of ornamentation.

Lacking comparative material, it is assumed that the citations to *C. dominicense* from Colombia (Anderson, 1929, p. 164) and Costa Rica (Gabb, 1881a, p. 344;

Olsson, 1922, p. 397) are the same as the Panamanian Gatun form. The Ecuadorian specimen from the Angostura Formation at Cueva de Angostura, figured by Olsson (1964, p. 53, pl. 6, figs. 1, 1a) appears to be a completely different species, much higher than wide, in contrast to the Gatun species, which is almost equidimensional.

Occurrence.—Baitoa Formation: Baitoa area (TU 1253, 1363, 1364)

Distribution.—Baitoa Formation, Dominican Republic.

Trachycardium (Dallocardia) tintinnabularum
(Maury)

Plate 14, figures 4–6; Plate 19, figure 1

Cardium (Trachycardium) tintinnabularum Maury, 1917, pp. 374, 429, 443, pl. (36)62, figs. 3, 3a; Vaughan *et al.*, 1921, p. 123.

Cardium tintinnabularum Maury. Pilsbry, 1922, p. 421.

Trachycardium tintinnabularum (Maury). Jung, 1969, p. 364.

Description.—

Shell rounded, rather thin and delicate, remarkable for its beautiful and curious ornamentation; valves sculptured with many regular fine ribs which in seven shells average forty-four; the ribs over the anterior portion are adorned with what resemble rows of miniature pendant sleigh bells which arise from the anterior edges but hang over upon the crests of the ribs, on the center of the valve the bells give place to small spines which first arise from the crest of the ribs but gradually are shifted to the posterior edges and finally come to lie in the interspaces. The spines at first small and erect become curved and bean-shaped on the posterior slope of the shell. Inner margin of valves serrate, teeth sharply defined. (Maury, 1917, p. 374)

Lectotype.—PRI 28987A (here designated; specimen figured by Maury, 1917, pl. 62, fig. 3).

Type locality.—Cercado Formation; Zone H, Río Cana at Caimito (Maury, 1917, p. 374) = locality TU 1230 (here restricted). Unfortunately, Maury did not cite the locality from which her figured specimens were obtained; however, the TU collections include 28 valves from the Cercado Formation on the Río Cana, 15 being from locality TU 1230, where we know that the party collected (Maury, 1917, pp. 173, 441). The color and preservation of the Maury syntypes agrees well with that exhibited by our specimens.

Material.—Two Maury syntypes, plus 45 right and 45 left valves from 21 localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
PRI 28987A ¹	20.0	20.5	7.0 ²	TU 1230 (see above)
PRI 28987B ¹	19.8	19.3	7.1 ⁴	TU 1230 (see above)
USNM 416207	23.4	25.5	9.6 ⁴	TU 1282

lectotype; ² left valve; ³ paralectotype (Maury, 1917, pl. 62, fig. 3a);

⁴ right valve

Remarks.—In this species there appears to be an evolutionary trend toward a reduction in the number

of radial costae: two of the three specimens available from the lower Miocene Baitoa Formation have 47 ribs, the third has 48; 19 specimens from the type area in the Cercado Formation have from 43 to 46 ribs, the mean falling between 44 and 45; the three immature specimens from the basal part of stratigraphically higher beds in the Gurabo Formation have a mean of 40 ribs per specimen. There is also a considerable variation in the nature of the surficial ornament on the costae. On many of the valves the “miniature pendant sleigh bells” of Maury continue across the medial portion of the valve and do not “give place to small spines”; on others the spines are present, but in neither case is the passage from the anterior to the posterior side of the ribs a “gradual” one. This shift in position occurs between one rib and that immediately posterior to it and takes place toward the anterior side of the median area of the valve; of 23 specimens examined it occurred between the 18th and 19th rib from the anterior end on seven (including the lectotype); between the 19th and 20th on five (including the paralectotype); on one specimen it was between ribs 16 and 17, and on one it was between 21 and 22. Most unusual is an aberrant specimen (see Pl. 14, fig. 6) on which the anterior 17 ribs are typically ornamented, then the succeeding four are completely smooth with no trace of ornament at any stage of growth, ribs 22 and 23 have posteriorly trending “bells”, rib 24 is smooth, with numbers 25 to 27 similar to 22, and ribs 28 and 29 are again smooth with the remaining costae typically ornamented. A topotype specimen exhibits another unusual feature with the tenth rib from the anterior end marked by closely approximated, transverse “bells” that are exceptionally strong and high resulting in the rib being a distinct, raised ridge trending toward the anteroventral margin.

The type lot (PRI 28987) consists of two specimens, a right and left valve, but they are not a pair, although Maury figured them in such a way as to suggest that they are. The hinge shown in her plate 62, figure 3, is the interior of the specimen shown as an exterior in her figure 3a. The left valve, shown in exterior view in figure 3, is here selected as the lectotype and the right valve shown as an exterior in figure 3a is the paralectotype.

Comparisons.—The ornamental features discussed above are similar to those present on specimens of *Trachycardium (Dallocardia) muricatum* (Linnaeus, 1758). In that species the line of demarcation between ribs with anteriorly directed scales and those with posteriorly directed ones usually occurs in the interval between the eleventh and fourteenth anterior ribs, and, according to Clench and Smith (1944, p. 8), the demarcation is “usually marked by 1 to 3 ribs which bear a double row of scales.” We have observed no similar double row on any examples of the present species.

Occurrence.—Baitoa Formation: Baitoa area (NMB 16938; TU 1363, 1364). Cercado Formation: Río Cana area (NMB 16838, 16839, 16844, 16985, 16995, 16989; TU 1230, 1282, 1301, 1422); Río Mao (NMB 16913; TU 1294, 1379). Gurabo Formation: Río Cana (NMB 16833, 16834, 16977). Unnamed formation: López area (TU 1446, 1447).

Distribution.—Baitoa and Cercado formations and shallow-water facies of the Gurabo Formation (and an unnamed correlative formation of the latter on the Río Yaque del Norte); Dominican Republic.

Trachycardium (Dallocardia) bowdenense
(Dall)

Plate 14, figure 7

Cardium (*Trachycardium*) var? *bowdenense* Dall, 1900, p. 1087.
NOT *Cardium* (*Trachycardium*) *bowdenense* Dall, 1915, p. 143
(= *C. silicatum* Mansfield, 1937).

Cardium (*Trachycardium*) *bowdenense* Dall, Woodring, 1925, p. 137,
pl. 18, figs. 14–16.

Trachycardium (*Dallocardia*) *bowdenense* (Dall), Jung, 1965, p. 452,
pl. 57, figs. 4, 5.

Description.—

Shell small, moderately inflated, slightly inequilateral, suborbicular, anterior end more convex than posterior and curving more broadly into base; umbos low, moderately inflated; sculpture consisting of 39 to 42 [44 on present specimen] low, subrounded ribs separated by interspaces of the same width or slightly narrower; interspaces usually crossed by fine concentric threads; ribs ornamented with a single row of more or less globular or transversely swollen beads; on the anterior 8 or 9 ribs the beads are largest and occupy the entire width of the ribs; on the next 7 ribs the beads are progressively shifted to the anterior side; of the succeeding 14 ribs on the first few the beads again occupy the entire width of the rib, but on the remainder the beads gradually are shifted to the posterior side and the interspaces between the ribs becoming slightly deeper; the 10 posterior ribs are characterized by a narrow anterior keel and a lower broader posterior part on which the beads lie; interspaces between posterior ribs relatively wide and shallow.

Length 19.5 mm; height 19.3 mm; diameter (right valve) 7 mm.

The valve measured is much larger than any other. The ribs on the middle of the shell are slightly narrower than those at either end. On most young shells the low posterior part of the 10 posterior ribs is absent, so that the beads lie in the interspaces. (Woodring, 1925, pp. 137–138)

Type material.—“Cotypes, USNM 115667” (Schuchert *et al.*, 1905, p. 128). Dimensions uncertain; Dall states (1900, p. 1088) “the shell is always small (alt. 15.5, lon. 15.5, diam. 9 mm. for the largest seen)” —presumably one of the cotypes, but not so stated.

Type locality.—Bowden Formation, Bowden, Jamaica (= loc. TU 705).

Material.—NMB G 16951 (herein figured).

Measurements.—NMB G 16951; length 6.9 mm, height 6.9 mm, diameter (right valve) 2.4 mm; locality NMB 16832.

Remarks.—In the original description of *C. bow-*

denense, Dall (1900, p. 1087) indicated that this is the form Guppy cited as *Cardium muricatum* Linnaeus, 1758, from the Bowden Marl. However, in the reference that he mentions, “Guppy, 1874”, the species does not appear on the page listed (p. 450) but on p. 442, and here Guppy lists *C. muricatum* only from the Recent and the Pliocene of Trinidad. In fact, I have not located any reference in which Guppy used this name for a Jamaican species.

Other than the possession of 44 rather than 42 radial ribs the present immature specimen agrees in all details of shape and rib ornamentation, as described by Woodring (1925, pp. 137–138), for the immature valves.

Comparisons.—The form from the Tampa, Florida, “*Silex* beds”, referred to *C. bowdenense* by Dall (1900, p. 1087; 1915, p. 143), has been named *Cardium* (*Trachycardium*) *silicatum* Mansfield, 1937 [p. 253, pl. 19, fig. 3]. It is shorter and more inflated than *T. bowdenense* and has relatively wider ribs. Dall compared his “variety” with the Recent species *C. muricatum* Linnaeus and noted that

it has about the same number of ribs (37 to 41) and the sculpture is much the same in character, but the similarities are all in miniature; the shell is always small . . . , less inflated proportionally than *C. muricatum* of the same size, with the ribs more compressed and crowded (Dall, 1900, p. 1087).

To this Woodring (1925, p. 138) added: “*C. bowdenense* has more rounded beads and none of the ribs bear two rows of beads.”

Occurrence.—Gurabo Formation: Río Cana (NMB 16832).

Distribution.—In the Dominican Republic known only from a single valve from the Gurabo Formation. Described from the Pleistocene Bowden Formation of Jamaica and reported (Jung, 1965) from the early Miocene Cantaure Formation of Venezuela.

Subgenus MEXICARDIA Stewart, 1930

Mexicardia Stewart, 1930, p. 263.

Type species.—*Cardium procerum* Sowerby, 1833, by original designation; Recent, Gulf of California to central Peru.

Diagnosis.—*Trachycardiids* with low, ventrally arched scales on ribs during early stages of growth, but becoming absent on the more anterior portion of valve; tending to persist, weakly, on the more posterior portion.

Trachycardium (Mexicardia) dominicanum
(Dall)

Plate 14, figures 8–10; Plate 19, figure 4

Cardium (*Trachycardium*) *sub-elongatum* Sowerby, Gabb, 1873, p. 250 (in part, not of Sowerby, 1841b).

Cardium (Trachycardium) dominicanum Dall, 1900, p. 1082; Dall, 1903, pl. 48, fig. 16; Maury, 1917, p. 373, pl. (36)62, fig. 1; Vaughan et al., 1921, p. 123; Pilsbry, 1922, p. 420; Ramírez, 1956, pp. 7, 11, 18, 19, 20, pl. 2, fig. 8.

NOT *Cardium (Trachycardium) dominicanum* Dall. Brown and Pilsbry, 1911, p. 367 [? = *T. dominicanum costaricanum* (Olsson, 1922)].

Cardium dominicanum Dall. Olsson, 1922, p. 398; Maury, 1925b, p. 276.

Trachycardium (Mexicardia) dominicanum (Dall). Woodring, 1982, p. 641.

Description.—

Shell ovate, solid, heavy, inflated, with high, conspicuous prosogyrate beaks, and a very short and heavy hinge; sculpture of twenty-seven similar, subequal, strong ribs, subtriangular in section, the longer side of the rib in each case inclining towards the middle line of the shell; interspaces very narrow, not regularly channeled, but rather formed by the sides of the ribs; the whole shell is covered with fine concentric lineation, and the summit of each rib when perfect carries a line of small nodules, usually rounded or oblong and transverse, and on a few of the ribs near the posterior end more or less $\wedge$ -shaped; shell nearly equilateral, internal margin fluted, upper part of the posterior margin serrate. (Dall, 1900, p. 1083)

Lectotype.—USNM 157524 (designated by Woodring, 1982, p. 641).

Type locality.—Locality TU 1294 (here restricted), Cercado Formation; Río Mao, bluff on left bank just above Paso de los Perros and ca. 5 km by road from Monción—San Jose de las Matas highway [= Bluff 3 of Maury, 1917; loc. USGS 8525], Dominican Republic.

Material.—More than 3000 valves from 19 localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
USNM 157524 ¹	21.0	28.2	12.0 ²	TU 1294 (see above)
USNM 416208	18.1	18.9	8.0 ²	TU 1294
USNM 416209	25.9	36.0	16.1 ³	TU 1379

lectotype; ² left valve; ³ right valve

Remarks.—*Trachycardium (Mexicardia) dominicanum* is presently known only from the lowermost part of the Cercado Formation on the Río Mao, where, however, it is exceedingly abundant; the TU collections contain more than 3000 valves. In a count of 100 valves; four specimens had 26 ribs; 18 specimens had 27 ribs; 57 specimens had 28 ribs; and 21 specimens had 29 ribs.

Of particular interest is the change in shape during growth; immature specimens are almost circular in outline with the same length and height and a rounded posterior margin; adult specimens reveal a much greater increase in the ratio of height to length, with a straightened posterior margin (compare Pl. 14, figs. 9 and 10). There is an even greater increase in valve inflation relative to length in the adult shell: the smallest of the illustrated specimens has a diameter of 8.0 mm (42% of the length), but the largest is 16.1 mm

(62% of the length). The number of ribs remains constant.

As noted by Woodring (1982, p. 641), Gabb forwarded the type lot of this species to Dall without locality data. This was apparently the result of Dall questioning Gabb's (1873, p. 250) referral of them to *Cardium subelongatum* Sowerby (1841b, p. 108), a synonym of *Acrosterigma magnum* (Linnaeus, 1758, p. 680), an identification that Dall described as "one of those puzzles which are inexplicable."

In the original publication, Dall cited *C. dominicanum* from "Oligocene shales near Gatun, on the line of the Panama Canal, Rowell; Oligocene of St. Domingo, Gabb". Subsequently, in the *Catalogue of Type Specimens*, the "Holotype" is listed as being from the "Oligocene. Near Gatun, Panama Canal" (Schuchert et al., 1905, p. 129). However, the species that occurs in that area is cited by Woodring (1982, p. 641) as being *T. dominicanum costaricanum* (Olsson, 1922). No specimen of *T. dominicanum dominicanum* has been found in the Gatun fauna, and no specimen labelled as "holotype" has been found in the Museum collections; accordingly, the left valve figured by Dall was designated as lectotype by Woodring.

Comparisons.—*Cardium costaricanum* Olsson, 1922 (p. 226, pl. 27, fig. 3) is, as noted by Woodring (1982, p. 641), a somewhat smaller form with fewer, "22 to 24 (generally 22) ribs". The surficial nodosity is confined to the ribs on the anterior slope, rather than being present on all of the anterior and median ribs, as well as, in most specimens, on the more medially located ribs of the posterior slope.

Occurrence.—Cercado Formation: Río Mao (TU 1294, 1379; NMB 16912–16918, 16922–16924, 16926–16930, 17269).

Distribution.—Known only from the basal part of the Cercado Formation, Dominican Republic.

Genus ACROSTERIGMA Dall, 1900

Acrosterigma Dall, 1900, pp. 1073, 1090.

Type species.—*Cardium Dalli* Heilprin, 1887, by original designation; Caloosahatchee Formation, Plio/Pleistocene, Florida.

Diagnosis.—Elongately-ovate cardiids with hinge strongly bent along arched dorsal margin of valves. Ribs smooth except for growth lamellae and slight pitting along posterior margins of costal surface, tending to be more pronounced on posteriormost costae.

Remarks.—Dall distinguished *Acrosterigma* as a "Section" of *Trachycardium* on the basis of the presence of "an elevated mesial rib internally, radiating from the umbonal cavity". As observed by Stewart (1930, p. 265) and subsequently confirmed by H. E. Vokes (1977, p. 160), this ridge is not universally pres-

ent in the type species and "therefore is considered of no systematic value" (Stewart, 1930, p. 266). However, the nature of the sharply bent hinge and the nearly smooth ribbing is distinctive and diagnostic; accordingly, Stewart elevated *Acrosterigma* to generic rank.

***Acrosterigma linguatigris* (Maury)**

Plate 14, figure 11; Plate 19, figure 3

Cardium (*Trachycardium*) *lingua-tigris* Maury, 1917, pp. 373, 443, pl. (36)62, fig. 2.

Cardium (*Trachycardium*) *linguatigris* Maury, Vaughan *et al.*, 1921, pp. 125, 151; Maury, 1925b, p. 278.

Cardium linguatigris Maury, Pilsbry, 1922, p. 421; Woodring, 1925, p. 139.

Shell with the general aspect of Guppy's Jamaican *C. lingua-leonis* but differing in the following respects: (1) the ribs in the Jamaican shell number 32, in the Dominican 42; (2) in the former the ribs are sharp and surmounted by a distinct keel with rippled edges, in the latter the ribs are broad, flat and smooth over all the central part of the valve and there is no keel apparent; (3) the beaks of the Jamaican shells are full and high, while those of the Dominican species are exceedingly low.

The ribs on the anterior slope are faint and finely, transversely rippled with growth lines. The last eight ribs on the posterior slope have a row of pustules along their posterior edge, the pustules being very minute except on the last two ribs. The posterior margin of the valve is deeply serrate; lateral teeth strong. (Maury, 1917, p. 374)

Description.—Shell subequilateral, elongate subovate with greatest height posterior to mid-length; umbones low, not prominent; anterior and ventral margins broadly and regularly rounded, more sharply rounded posteroventrally into the arched, deeply serrated posterior margin; surface with 39 to 42 low, subrounded radial costae separated by narrow interspaces; ribs on the anterior third of valve ornamented by low, arched and shingled concentric lamellae, the convex side of the arch directed dorsally; median ribs slightly narrower than anterior ones and lacking ornament; posterior 12 or 13 ribs very low and broad with almost linear interspaces; the more anterior of these with a shallow median groove, and the last eight marked by distant, small beads near their posterior side; ribs becoming progressively larger and more closely approximate marginally. Hinge typical of the genus; anterior and ventral margins internally denticulated; adductor scars slightly impressed.

Holotype.—PRI 28985.

Type locality.—Cercado Formation; Zone H, Río Cana at Caimito (Maury, 1917, p. 374) = locality TU 1230 (here restricted).

Measurements (in mm).—

specimen	length	height	diameter	locality
PRI 28985 ¹	45	47 ²	13 ³	TU 1230 (see above)
NMB G 16952	40.5	52.7	≈31.5 ⁴	NMB 16817

¹ holotype; ² incomplete; ³ right valve; ⁴ paired valves

Material.—Three internal molds, plus two paired

valve specimens and two left and three right valves from nine localities.

Remarks.—Three of the four single valves, plus two paired valve specimens in the collections have 39 or 40 ribs; a small, dorsally incomplete valve from the Río Cana area (loc. NMB 16825) appears to have 42, the number cited by Maury as present on the holotype.

Comparisons.—The Bowden Pleistocene species *Cardium inconspicuum* Guppy, 1866a [p. 293, pl. 18, fig. 12; see also Woodring, 1925, p. 138, pl. 19, figs. 1, 2] is somewhat similar, but is proportionately shorter and more elongate with the "anterior 10 to 13 ribs ornamented with transverse or slightly oblique beads" (Woodring, 1925, p. 128). *Cardium* (*Trachycardium*) *waylandi* Woodring, 1925 [p. 139, pl. 19, figs. 3, 4], also from the Bowden Formation, is a much more broadly ovate form with 35 ribs that are, however, identical in shape and surface ornament to those on the present species except that only the last five of the posterior ribs have nodose ornamentation.

Occurrence.—Cercado Formation: Río Gurabo (NMB 15884). Gurabo Formation: Río Cana area (TU 1354, 1382³, 1415³, 1422; NMB 16817, 16820, 16825); Santiago area (TU 1206³).

Distribution.—Known only from the Cercado Formation and shallow-water facies of the Gurabo Formation, Dominican Republic.

Subfamily FRAGINAE Stewart, 1930

Diagnosis.—

Shell inequilateral in outline; umbonal ridge strong in most; posterior margin meeting ventral margin at a 90° angle or less; ribs equally emphasized throughout, intercostal spaces with concentric striations, an intritacalx (chalky surface layer) present in most well-preserved specimens; posterior margin usually notched; hinge relatively short, angulate (*i.e.*, anterior and posterior sections meeting at a sharp angle). (Keen, 1980, p. 11)

Genus TRIGONICARDIA Dall, 1900

Trigonicardia Dall, 1900, p. 1075.

Type species.—*Cardium graniferum* Broderip and Sowerby, 1829, by original designation; Recent, Gulf of California to northern Peru.

Diagnosis.—Subtrigonal to subquadrate cardiids marked by high umbones, with a strong posteroventral angulation, the posterior side flattened to mesially sulcate, the anterior rounded.

Subgenus TRIGONICARDIA *sensu stricto*

Diagnosis.—Ribs commonly flat-topped, those on the anterior and median portion of the valve stronger than those of the posterior slope; all ribs marked by an intritacalx (see D'Attilio and Radwin, 1971, pp.

³Represented by internal molds only.

344–347) that includes discrete nodes, more or less transverse in position on the tops of the ribs with the spaces between the ribs smooth on unworn specimens. Interspace area marked by ladder-like straight to somewhat curved, or obliquely trending raised threads that may or may not extend up the sides of the ribs, but not onto their upper surface.

Remarks.—I cannot agree with the assignment of some of the species here referred to *Trigoniocardia* sensu stricto to the subgenus *Apiocardia* Olsson, 1961, as was done by Woodring (1982, p. 643). Although a number of species do have a general outline with a shorter and higher valve than is characteristic of that of *T. granifera* (Broderip and Sowerby, 1829), the type species of *Trigoniocardia*, both *T. aminensis* (Dall, 1900) and *T. haitiensis* (Sowerby, 1850), the two Dominican species assigned to *Apiocardia* by Woodring, have an intritacalx similar to that present on *T. granifera* and unlike that present on *Apiocardia obovale* (Sowerby, 1833) (see Olsson, 1961, pl. 38, fig. 4). On that species the radial ribs tend to be broader and lower than those on the species of *Trigoniocardia* (*Trigoniocardia*), with those anterior to the relatively lower and more rounded posteroventral angulation being marked only by low, rounded nodules along their posterior edge, the median and anterior portions being smooth. The strongest rib — that marking the posteroventral angulation — may have nodes trending across its dorsal surface; the rib immediately posterior to it tends to have small nodes on its anterior side and other ribs on the posterior surface are smooth.

***Trigoniocardia (Trigoniocardia) haitiensis haitiensis*
(Sowerby)**

Plate 15, figures 1, 2; Plate 18, figure 7

Cardium Haitense Sowerby, 1850, p. 52, pl. 10, fig. 11 (upper figure); Guppy, 1866b, p. 575; Guppy, 1867, p. 163 (in part, Haiti reference only) [reprinted: Harris, 1921, p. 184]; Guppy, 1876, p. 531; Guppy, 1911, p. 5 [reprinted: Harris, 1921, p. 309].

Cardium (Fragum) Haitense Sowerby, Gabb, 1873, p. 251.

Cardium (Trigoniocardia) haitense Sowerby, Dall, 1900, pp. 1103, 1105; Maury, 1917, pp. 375, 427, et seq., pl. (36)62, figs. 5, 5a; Maury, 1920, p. 35; Vaughan et al., 1921, pp. 123, 129, 145, 151; Pilsbry, 1922, p. 421.

NOT Cardium (Trigoniocardia) haitense haitense Sowerby. Woodring, 1925, p. 142.

Cardium (Trigoniocardia [sic]) haitense Sowerby, Ramirez, 1950, p. 36, pl. 7, fig. 5; Ramirez, 1956, p. 13, et seq.

Trigoniocardia haitensis haitensis (Sowerby). Pflug, 1961, p. 80, pl. 24, figs. 10, 11 (lectotype).

Trigoniocardia haitensis (Sowerby). Jung, 1965, p. 454; Woodring, 1982, pp. 642, 644.

Testa oblique subovata gibbosa, radiatim costata, lateribus brevibus, costis quatuor et viginti, quadratis, graniferis, interstitiis creberrime rugulosis; angulo postico rotundato ex umbone ad marginem inferiorem posticam decurrente. (Sowerby, 1850, p. 52)

Description.—Shell inflated with full and high um-

bones situated slightly in advance of anterior third of total length; anterior and anteroventral margins rounded, flattening posteriorly to a strongly angulate posteroventral corner; posterior margin almost vertically truncate, but rounding relatively sharply into the arched dorsal one; surface marked by a strong ridge extending from the posterior edge of the umbonal inflation to the posteroventral marginal angulation; ornament of radial costae, 13 to 16 (commonly 14 or 15) anterior to the postero-umbonal ridge and 9 to 11 (commonly 10) on posterior slope; ribs tending to be flat-topped except for the noded surficial intritacalx, those on the medial portion of valve separated by entrenched interspaces with flat bottoms, as wide as ribs, and narrow margins that project up along the sides of the ribs and terminate at a distinct groove on the rib side; these interspaces sculptured by relatively coarse concentric comarginal threads, concavely arched on the flat-bottomed areas but angulated to a lateral or ventral trend on the marginal sides; toward the anterodorsal side of valve the raised margins tend to disappear with the intervening interspaces of equal or slightly greater width than the lower radials; ribs on the posterior slope narrower than those on the median area and separated by narrower and relatively shallow interspaces; crests of all ribs ornamented by a thin, deciduous intritacalx marked by the presence of discrete nodules, more or less transverse in position, with internodular spaces smooth or marked only by faint growth rugae and of a width about equal to that of the nodules.

Lectotype.—BMNH LL 11356 (designated by Pflug, 1961, p. 81).

Type locality.—Locality TU 1375 (here restricted), Cercado Formation; Río Gurabo, west side, at long bluff approximately 0.5 km below the mouth of Arroyo Palero, or about 5 km (airline) above the ford on Los Quemados-Sabaneta road, Dominican Republic.

Material.—A total of 1355 valves from 94 localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
BMNH LL 11356 ¹	18	23	10 ²	TU 1375 (see above)
USNM 416213	15.5	17.6	7.3 ²	TU 1359
NMB G 16953	18.2	21.3	9.1 ²	NMB 15898

¹ lectotype; ² left valve

Remarks.—*Trigoniocardia (Trigoniocardia) haitensis* (Sowerby) is an exceedingly variable species with specimens from the same locality showing notable differences in the degree of inflation of the valves, in the angularity of the postero-umbonal ridge, in the posterior margin that varies from slightly concave to convex in outline, and in the number of ribs which varies, not only at one horizon (as shown in Table 2), but also with increasing paleo-water-depth (Table 3).

Certain of the more extreme variations have been

Table 2.—Numbers of ribs anterior and posterior to posteroventral angulation in 85 valves of *Trigoniocardia (Trigoniocardia) haitensis* from Arroyo Bajón (loc. TU 1379).

no. of specimens	anterior	posterior
14	13	10
1	13	11
5	14	9
49	14	10
3	14	11
9	15	10
1	15	11
2	16	10
1	16	11

previously noted and named by Maury in 1917; her "variety" *cercadicum* and "species" *sambaicum* are here considered to represent ecologic variants of *T. haitensis*. While these ecophenotypic variations may well be, as suggested by Dr. Steven Stanley (written comm., 1987), a result of different water depths, they are sufficiently distinctive as taxonomic elements to merit inclusion in this study.

Table 3.—Numbers of ribs anterior and posterior to posteroventral angulation in 310 specimens of *Trigoniocardia (Trigoniocardia) haitensis* from facies in the study area. Numbers are expressed in terms of percent of the total number of valves measured from each area.

	anterior			
	13	14	15	16
nearshore Cercado Formation ¹	14	67	17	3
offshore Cercado Formation ²	14.5	45.5	34.5	5.5
shallow-water Gurabo Formation ³	2	31	50	17
	posterior			
	8	9	10	11
nearshore Cercado Formation ¹	—	3	86	11
offshore Cercado Formation ²	1	21	73	5
shallow-water Gurabo Formation ³	—	7	75	18

¹ Bluff 3 and Arroyo Bajón area [150 valves]; ² Río Mao and Río Gurabo areas [110 valves]; ³ Río Mao, Río Gurabo, Río Cana, and Santiago areas [50 valves]

Trigoniocardia haitensis has been reported from numerous fossil localities in the Caribbean region. The majority of these records have been shown to be erroneous identifications. Guppy's (1867, p. 163) report of its presence in the Pliocene fauna of Trinidad was based upon specimens that were subsequently cited as types of *Cardium (Trigoniocardia) maturense* Dall, 1900 [p. 1105; 1903, pl. 48, fig. 7], and Guppy's 1877 record of its presence in the Recent fauna of the Gulf of Paria was said by Dall (1901, p. 388) to have been based upon "*Cardium antillarum* Orbigny or a related species."

Comparisons.—The shell identified by Woodring (1925, p. 142, pl. 19, figs. 8, 9) as *Cardium (Trigoniocardia) haitense haitense*, "the most abundant of all Bowden bivalves", differs from the present form in possessing fewer ribs, a generally less sharply angulate posterior segment, and in having the anterior lateral tooth more closely adjacent to the cardinals. Counts

of ribs on 50 Bowden specimens in the TU collections (loc. TU 705) are shown in Table 4. These Bowden specimens are sufficiently similar to the Dominican form as best to be considered a subspecies rather than a wholly different form.

Occurrence.—Cercado Formation: Río Cana area (NMB 16835, 16857, 16984, 17005; TU 1230, 1420); Río Gurabo area (NMB 15878, 15882, 15890, 15895–15902, 15905, 15906, 15908, 15913–15915, 15919; TU 1297, 1298, 1358, 1359, 1374, 1375, 1377, 1418, 1419); Río Mao (NMB 16802, 16910, 16912–16918, 16922–16924, 16926–16932, 17269; TU 1294, 1379, 1410). Gurabo Formation: Río Cana (NMB 16817, 16824, 16833, 16834, 16866, 16971); Río Gurabo (NMB 15814, 15873–15877; TU 1211, 1215, 1277); Río Mao area (TU 1225, 1293, 1409); Río Amina area (TU 1219, 1220, 1412, 1455, 1456); Santiago area (NMB 17268; TU 1205, 1227A, 1250, 1353, 1404).

Distribution.—Although, according to the literature, widely distributed in the Caribbean Miocene/Pliocene

Table 4.—Numbers of ribs anterior and posterior to posteroventral angulation in 50 specimens of *Cardium (Trigoniocardia) haitense* subspecies from Bowden, Jamaica (loc. TU 705). Numbers are expressed in terms of percent of the total number of valves measured.

	anterior				posterior		
	11	12	13	14	8	9	10
percent of total	4	28	56	12	6	86	8

faunas, *Trigoniocardia haitensis haitensis* appears to be confined to the Cercado and shallow-water Gurabo faunas of the Dominican Republic (see discussion above). The species is especially common on the Río Gurabo below Arroyo Palero; accordingly, the type locality is here restricted to locality TU 1375.

Trigoniocardia (Trigoniocardia) haitensis cercadica (Maury)

Plate 15, figures 3–5; Plate 18, figure 5

Cardium Haitense Sowerby, 1850, pl. 19, fig. 11 (in part, lower of two views, *vide* Maury, 1917, p. 375).

Cardium (*Trigoniocardia*) *haitense* variety *cercadicum* Maury, 1917, pp. 376, 427, pl. (36)62, fig. 6.

Cardium (*Trigoniocardia*) *haitense cercadicum* Maury, Maury, 1920, pp. 35, 36; Vaughan *et al.*, 1921, pp. 124, 129; Woodring, 1925, p. 143, pl. 19, figs. 10, 11.

NOT *Cardium* (*Trigoniocardia*) *haitense cercadicum* Maury. Hubbard, 1920, p. 117, pl. 19, fig. 8.

Cardium (*Trigoniocardia*) *aminense* Dall, Vaughan *et al.*, 1921, p. 145 [not of Dall, 1900, p. 1104; see discussion under *T. (T.) aminensis* (p. 119 herein)].

Cardium (*Trigoniocardia* [sic]) *haitense cercadicum* Maury, Ramírez, 1950, p. 36, pl. 7, fig. 6; Ramírez, 1956, pp. 13, 18.

Trigoniocardia haitensis cercadicum (Maury). Pflug, 1961, p. 81; Weisbord, 1964, p. 259.

Description.—

This form differs from the typical in its sharply angulated posterior slope and produced posterior margin. Ribs usually ten on the truncation, fourteen on the body, ornamented with nodules pointing upwards. (Maury, 1917, p. 376)

Lectotype.—PRI 28991 (here designated), specimen figured by Maury, 1917, pl. 62, fig. 6. Pflug's statement (1961, p. 81, freely translated) to the effect that "since Maury in her text explicitly referred to the lower figure of Sowerby, 1850, the corresponding figure in the Heneken collection could, if we wished, be considered as type of the subspecies" was not a formal type designation.

Type locality.—Cercado Formation; Río Mao, Bluff 2, Cercado de Mao (Maury, 1917, p. 376).

Material.—A total of 119 valves from 33 localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
PRI 28991 ¹	14.0	17.8	7.5 ²	Bluff 2, Río Mao
USNM 416214	10.2	13.0	5.5 ³	TU 1219
USNM 416215	9.4	12.4	5.8 ²	TU 1219
USNM 416216	8.7	12.1	4.9 ²	TU 1213

¹ lectotype; ² left valve; ³ right valve

Remarks.—*Trigoniocardia haitensis cercadica* appears to represent a more offshore, deeper-water form than *T. haitensis haitensis*, being confined to the deeper facies of the Cercado and to the Gurabo formations. Specimens in the TU collections from the Bowden Formation of Jamaica (loc. TU 705) agree well with those from the Dominican Republic except that they tend to be somewhat more elongate in proportion to height and to have a postero-umbonal ridge that is, in most cases, slightly less sharply angulated.

Maury (1920, p. 36) reported "several internal molds that appear to be this variety" [*i.e.*, *haitense* var. *cercadicum*] from the Quebradillas and Ponce areas of Puerto Rico. However, the specimen figured and described by Hubbard (1920, p. 117, pl. 19, fig. 8), apparently from the Quebradillas Limestone, differs in shape and surface ornament with the ribs "anterior to

the truncation having flat tops sloping anteriorly . . . giving an asymmetric V-shaped cross-section" and bearing "inverted V-shaped nodules."

Examination of the specimens identified and listed as *Cardium* (*Trigoniocardia*) *aminense* Dall by Vaughan and Woodring in Vaughan *et al.* (1921, p. 145), localities USGS 8516, 8519, and 8544 on the Río Amina, Río Mao, and Río Gurabo respectively, reveals that all are to be referred to the present form. The misidentifications may have been influenced by the fact that Dall clearly had his locality in error; the type of *T. aminensis* is a species from the Baitoa Formation, as attested by the nature of the matrix within the valve, as well as by the fact that the species is abundant in the collections from that formation, with no specimens from Potrero on the Río Amina, cited as type locality by Dall (1900, p. 1104) nor from any other locality within the Cercado or Gurabo formations.

Comparisons.—*Trigoniocardia haitensis cercadica* agrees with the typical *T. haitensis haitensis* in the number of ribs on the anterior and posterior areas of the valves, but differs in the following: (1) smaller adult size; (2) more sharply angulate postero-umbonal ridge, resulting in a more steeply descending posterior slope; (3) the flat-topped ribs being straight-sided or even overhanging the flat-bottomed interspaces that lack the raised, trench-like sides of those present on *T. haitensis*; (4) concentric threads that traverse the interspaces being highly variable in pattern from straight to slightly convex, and with an anteroventral trend as they progress across the median and anterior parts of the valve; and (5) intritacal nodules on the median and anterior ribs tending to be confined to the posterior half of the rib width. On some specimens the nodules may extend almost entirely across the ribs; however, in such cases the nodes are narrowed anteriorly with their greatest width on the posterior half where there may be some vertical interconnection between them. Nodules on the ribs on the posterior side of the umbonal angulation vary from teardrop in shape (present only on the center of the rib) to more rounded, relatively transverse forms.

Occurrence.—Cercado Formation: Río Cana (TU 1230); Río Mao (NMB 16910). Gurabo Formation: Río Gurabo (NMB 15804, 15805, 15812, 15814, 15815, 15836, 15842, 15846, 15860, 15863–15865, 15869, 15871, 15934, 15962, 15964, 15966, 16808, 16810; TU 1210, 1211, 1213, 1215, 1278); Río Mao (TU 1293); Río Amina area (TU 1219, 1220, 1371); Santiago area (TU 1227A, 1250). Unnamed formation: López area (NMB 17273).

Distribution.—Gurabo Formation and deeper-water facies of Cercado Formation, as well as an unnamed correlative formation; Dominican Republic. ?Quebradillas Limestone, Puerto Rico, Pliocene; ?Bowden Formation, Jamaica; Pleistocene.

**Trigoniocardia (Trigoniocardia)
haitensis sambaica (Maury)**

Plate 15, figures 6–8; Plate 18, figure 8

Table 5.—Numbers of ribs anterior and posterior to posteroventral angulation in 75 valves of *Trigoniocardia (Trigoniocardia) haitensis sambaica* from the Cercado and Gurabo formations.

no. of specimens	anterior	posterior
2	15	9
1	15	10
16	16	9
24	16	10
1	16	11
11	17	9
12	17	10
2	17	11
2	18	9
3	18	10
1	19	10

Description.—

Cardium (Trigoniocardia) sambaicum Maury, 1917, pp. 376, 451, pl. (36)62, fig. 7; Vaughan *et al.*, 1921, p. 146.

Cardium sambaicum Maury. Hubbard, 1920, p. 116; Spieker, 1922, p. 137.

Trigoniocardia sambaicum sambaicum (Maury). Weisbord, 1964, p. 259.

Shell subquadrate, rather thin, anterior margin roundly truncate, posterior truncate, base rounded; umbonal slope roundly angulated; inner margin deeply serrate; ribs on the body seventeen, on the truncation ten, ribs with only a few nodules preserved but showing definite marks of having been all nodose; interspaces narrower than the ribs, marked strongly by transverse growth lines. Altitude 17, length 17, diameter 14 mm.

This species resembles *Trigoniocardia* but is squarer and has more ribs. (Maury, 1917, p. 376)

Lectotype.—PRI 28992 (here designated) (specimen figured by Maury, 1917, pl. 62, fig. 7).

Type locality.—Gurabo Formation; “Samba Hills at an approximate altitude of 540 feet” (Maury, 1917, p. 376). Maury (1917, p. 170) states that when “coming down the road” over the Samba Hills between Rompino and the Las Caobas plain “the party branched off into an arroyo from the west, where a yellow fossiliferous clay with Pectens was found at an altitude of 540 feet.” The geologic section at the locality is given by Maury (1917, p. 451).

Material.—A total of 331 valves from 30 localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
PRI 28992 ¹	16.1	17.2	7.2 ²	(see above)
NMB G 16954	18.6	21.7	8.5 ³	NMB 16825
USNM 416217	13.9	16.2	7.6 ²	TU 1449

¹ lectotype; ² right valve; ³ left valve

Remarks.—Specimens from localities TU 1403 and 1405 at Arroyo Babosico near Las Charcas, east of Santiago, collected from turbidity-flows into the Gurabo Formation, reveal a complete transition from typical *T. haitensis haitensis* to *T. haitensis sambaica*. However, it is not possible to determine whether or not they came from waters of different depths as the sediments cascaded downslope.

Comparisons.—*Trigoniocardia haitensis sambaica* differs from *T. haitensis haitensis* primarily in possessing a few more radial ribs on the anterior portion of the shell; the “squarer” shape mentioned by Maury in her description of her single specimen proves to be variable, with some specimens of *T. haitensis haitensis* having the same square outline and some of *T. haitensis sambaica* being ovate.

The ribs anterior to the relatively weak postero-um-

bonal angulation on 75 valves of *T. haitensis sambaica* vary between 15 and 19 in number, as contrasted with the 13 to 16 on *T. haitensis haitensis*; those on the posterior area number nine to 11 in both forms. The distribution of ribs per valve is shown in Table 5. The data presented there show that 88% of the valves have 16 or 17 anterior ribs, with 96% having 10 or 11 posterior ones.

Occurrence.—Cercado Formation: Río Cana (NMB 16837, 16838, 16842, 16983, 16986); Río Gurabo (TU 1297). Gurabo Formation: Río Cana area (NMB 16814, 16817, 16818, 16821, 16825, 16828, 16832, 16833, 16873; TU 1354); Río Gurabo (NMB 15814, 15874); Río Mao area (TU 1225); Santiago area (NMB 17266; TU 1250, 1403, 1405, 1448, 1449, 1453A).

Distribution.—Known only from the Dominican Republic, where it appears to be confined to the uppermost Cercado Formation and more shallow-water facies of the Gurabo Formation, except for those from locality NMB 15814 (= loc. TU 1213), which may represent a thin turbidity-flow lens.

**Trigoniocardia (Trigoniocardia) marcanoi,
new species**

Plate 15, figures 9, 10; Plate 18, figure 3

Etymology of name.—In honor of Professor E. de J. Marciano F. (see Remarks below).

Description.—Shell subquadrate in outline in immature stages, becoming high-ovate in adults with high, prosogyrate umbones situated slightly in advance of anterior third of length; prominent, roundly subangulate ridge extending to posteroventral margin; anterior and ventral margins broadly and regularly rounded, posterior very slightly concave, almost straight; surface ornamented by 21 to 24 radial costae, usually 22 or 23, of which 13 or 14 are anterior to the umbonal ridge and nine are on posterior slope; costae separated by entrenched interspaces with flat bottoms and margins that project up along the sides of the ribs at a distinct angle giving them a subtriangular appear-

ance; on the median portion of the valve the flattened rib crests progressively widen anteriorly from the umbonal ridge to the anteroventral area, but the interspaces simultaneously narrow so that the distance between the midpoints of the crests remains essentially of the same width, the interspaces narrowing by means of the progressive narrowing of their lateral margins, that on the anterior side becoming almost vertical; width of flat-bottomed segment essentially unchanged and remaining constant up to between the fifth and sixth anteriormost ribs, anterior to which the space progressively narrows as the ribs decrease in width; costae on posterior area smaller and more closely approximate, but with similar interspace structures; interspace areas ornamented with numerous, relatively fine, transverse threads that characteristically are convexly downcurved on the flattened portion and become roundly angulated to a distinct ventral trend on the marginal areas; rib-tops anterior to the angulation with a smooth, rounded intritacalx interrupted by numerous broad and relatively thin spoon-shaped nodes; nodes on ribs posterior to angulation, narrow and almost pointed. Hinge with strong anterior cardinal in left valve and posterior cardinal in right, the others being so reduced as to be essentially absent; anterior lateral adjacent to cardinals, posterior more distant; inner margin strongly crenulated, the crenulations on median portion extending well up into interior of valve.

Holotype.—USNM 416219.

Type locality.—Locality TU 1420, Cercado Formation; Arroyo Bellaco (or Beyaco on some maps), a tributary of the Río Cana from the east; first canyon above the ford at Las Caobas Adentro, 3 km southwest of Las Caobas, Dominican Republic.

Material.—A total of 73 specimens from two localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
USNM 416219 ¹	16.4	20.8	7.2 ²	TU 1420
USNM 416218 ³	14.6	18.6	6.8 ⁴	TU 1420
USNM 416232 ⁵	8.9	10.1	3.8 ²	TU 1420
PRI 33063 ⁶	16.4	21.5	7.3 ²	TU 1420

holotype; ² right valve; ³ paratype A; ⁴ left valve; ⁵ paratype B; ⁶ unfigured paratype

Remarks.—The name given this new species is an acknowledgment of our indebtedness to Prof. Eugenio de Jesus Marciano F., Professor of Biology at the Universidad Autónoma de Santo Domingo and former Director of the Museo Nacional de Historia Natural in Santo Domingo. Among his many kindnesses to us, Prof. Marciano called to our attention the localities along the upper reaches of Arroyo Bellaco.

Comparisons.—*Trigoniocardia* (*Trigoniocardia*) *marcanoii*, n. sp., superficially resembles some forms

Table 6.—Numbers of ribs anterior and posterior to posteroventral angulation in 50 valves of *Trigoniocardia* (*Trigoniocardia*) *marcanoii*, n. sp., from locality TU 1420.

	<i>anterior</i>				<i>posterior</i>		
	<i>12</i>	<i>13</i>	<i>14</i>	<i>15</i>	<i>8</i>	<i>9</i>	<i>10</i>
25 right valves	—	7	12	6	5	20	—
25 left valves	1	15	8	1	1	23	1
Total	1	22	20	7	6	43	1

of *T. (T.) haitensis haitensis* but differs in the shape of the adult valves, which are more slender with a more regular rounding of the anterior and ventral margins. There is also a tendency to have fewer radial costae that are of a different shape with a different type of nodal ornament on their intritacalx. The valves tend to be larger than those of *T. (T.) haitensis cercadica*, have a less strongly angulate postero-umbonal fold, and also differ in number of radial ribs and their ornament. A count of the ribs on 50 valves of *T. (T.) marcanoii* from locality TU 1420 is shown in Table 6.

Occurrence.—Cercado Formation: Río Cana area (TU 1420, 1421).

Distribution.—Known only from above the coral reef on Arroyo Bellaco, upstream from the ford at Las Caobas Adentro, southwest of Las Caobas, in the Cercado Formation, Dominican Republic.

Trigoniocardia (*Trigoniocardia*) *clinocostata*, new species

Plate 16, figures 1–3; Plate 18, figure 4

Etymology of name.—*L. clino* = slope + *L. costa* = ribbed.

Description.—Shell subquadrate in outline with high, prosogyrate umbones situated slightly anterior to mid-length of dorsal margin; a sharply angulate ridge extending to posteroventral margin and separating the steeply sloping posterior side of valve from more broadly and roundly inflated median and anterior areas; posterior margins straight, sharply angulated posteroventrally into broadly and regularly rounded ventral and anterior margins; surface ornamented by 21 to 24 radial costae, commonly 22 on the left valve and 23 or 24 on the right; of these, nine to 11 ribs, commonly 10, are on the posterior slope; posterior ribs relatively broad and low, about four times the width of the narrow interspaces; the tops of the more anterior of these ribs have a slight slope dorsally, but those adjacent to the angulation are flat-topped, with the interspaces marked by transverse threads that tend to rise along the margins of the higher costae and are essentially equal in height to the dorsally sloping edges of the more anterior ones; posteroventral angulation marked, on the left valve by a strong, high rib that articulates between two slightly narrower and less pronounced ribs

on the right valve, the posterior of these ribs being immediately adjacent to the rib on the posterior slope, but wider and ornamented similarly to those anteriorly adjacent to it; costae on median portion of valve moderately broad and flat in immature stages, but developing an anteriorly sloping surface on the adult segments; the costae on the anteriormost part of the valve tending to maintain a flat-topped profile; interspace between the ribs on the angulation of the right valve and those immediately anterior to it approximately as wide as the rib, those between the ribs anterior to this about one-half as wide as the adjacent costae; interspaces marked by relatively strong transverse threads that trend at an angle to the ventral margin with their anterior ends lower than the posterior ones. Intritacalx of small, rounded nodes situated upon the higher, posterior portion of the costae on the angulation and on the medial part of the valve, tending to become elongately transverse on the more anteriorly situated ribs but not reaching the anterior margin of the rib tops; nodes on posterior costae tending to be slightly elongated dorsoventrally and situated on the median portion of the rib top. Hinge typical of the genus (see Pl. 16, fig. 1b); internal margins strongly denticulated by inner sides of the upturned ribs, with the folds on the median area extending well up into the central part of the valve with that of the first rib anterior to the angulation extending into the subumbonal area.

Holotype.—USNM 416220.

Type locality.—Locality TU 1445, unnamed formation; Río Yaque del Norte, west bank, at "La Ventana" tunnel (López-Angostura hydroelectric project), between hard ledges just upstream from entrance to tunnel, Dominican Republic.

Material.—A total of 24 valves from three localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
USNM 416220 ¹	11.0	14.1	4.9 ²	TU 1445
USNM 416221 ³	8.7	11.1	4.5 ⁴	TU 1445
USNM 416225 ⁵	8.6	10.9	4.3 ²	TU 1445
PRI 33064 ⁶	7.6	9.6	3.8 ²	TU 1445

¹ holotype; ² left valve; ³ paratype A; ⁴ right valve; ⁵ paratype B; ⁶ unfigured paratype

Remarks.—The fact that *Trigoniocardia* (*Trigoniocardia*) *clinocostata*, n. sp., is known solely from localities immediately upstream from the gigantic coral reef at La Angostura suggests that its presence is evidence of an ecologic environment different from that present at other localities. At all three localities where the species occurs the material was found in relatively hard, calcareous ledges that contain a fauna of more shallow-water aspect than that normally present in the Gurabo deposits. Bold (1988, p. 14) also noted that the ostracode fauna in this area is indicative of "special

conditions". In his opinion, these conditions are a result of an increased calcium carbonate content in the environment, which is not unreasonable in view of the presence of the Angostura reef. Presumably this area is a shallow back-reef facies, which is not developed elsewhere in the section, as there is not a comparable reef development in the Gurabo Formation elsewhere.

Comparisons.—*Trigoniocardia* (*Trigoniocardia*) *clinocostata* most closely resembles *T. (T.) aminensis* (Dall, 1900) from the Baitoa Formation, and may well be a descendant of that species. It differs, however, in (1) its more quadrate shape, being broader in proportion to the height, especially in the more immature specimens; (2) the gently sloping rib-tops on the more dorsal posterior costae and on the median portion of the valve; and (3) the details of the intritacalx nodes, which tend, on *T. (T.) aminensis*, to be elongate over most of the costae anterior to the posteroventral angulation and, on the posterior slope, to be closer together and to be "tear-shaped . . . with the small end of the drop upwards" (Dall, 1900, p. 1104). *Trigoniocardia* *matuensis* (Dall, 1900) is similar in the occurrence of sloping rib surfaces, but differs in having fewer ribs that possess an intritacalx in which the nodes are transversely elongate and extend all the way across the rib-tops. The pronounced high costa on the posteroventral angulation of the left valve suggests that one present on both valves of *T. (T.) haitiensis cercadica* (Maury, 1917), but that species is much narrower in proportion to the height of the valve and is ornamented by a wholly different nodal intritacalx pattern.

Occurrence.—Unnamed formation: López area (TU 1443, 1444, 1445).

Distribution.—Known only from the type area in the Dominican Republic.

Trigoniocardia (?*Trigoniocardia*) *leptopleura*, new species

Plate 16, figure 4; Plate 18, figure 2

Etymology of name.—*G. leptos* = thin + *G. pleuron* = rib.

Description.—Shell with high, relatively narrow umbones situated slightly in advance of anterior third of the length; posterior margin almost vertically truncate, rounding dorsally into dorsal margin and more sharply curved ventrally into the (apparently) broadly and regularly rounded ventral and anterior margins; posteroventral umbonal ridge strong, the area behind it falling rapidly to the posterior margin, with the anterior side relatively strongly convex; ornamentation of 24 radial costae, 14 on anterior portion, 10 posteriorly; first six costae on anterior slope approximately as wide as their interspaces, ribs becoming slightly narrowed on median area of valve as interspaces become progressively wider until immediately in advance of posterior an-

gulation the interspaces are more than three times the width of rib-tops; costae and interspaces on posterior slope of approximately equal width; interspaces on anterior and median area centrally flat-bottomed with sloping margins that become somewhat angulated on the broader ones of the median area, where the side has a relatively steep lower slope that becomes subangulately rounded medially, passing into a relatively concave shape as they rise toward the rib-crest where they terminate at a narrow, smooth, threadlike ridge trending along the rib-side; interspaces on posterior slope essentially round-bottomed; all interspaces marked by relatively strong, smooth-topped threads that are more or less directly transverse to those of anterior slope but becoming roundly convex on flat bottoms and lower slopes of those on the medial surface, with a sharply rounded curve at the medial angulation on the rib-sides becoming straight to posteriorly trending on the upper segment of the rib-side. Intritacalx on rib-tops thick, with elongated nodular crest, the individual nodules broadening ventrally along the rib with an increasingly sharp curve to a raised, moderately narrow, transverse node whose lateral margins project over the side of the interspace area and whose base drops relatively steeply to the lower segment of the succeeding node; intritacalx on ribs of posterior slope with a narrower crest and terminal nodules more centrally acute as compared to their lateral width and a more gradual basal ventral trend. Hinge typical of the genus; posterior margin serrate, the preserved part of anterior margin relatively smooth.

Holotype.—USNM 416223.

Type locality.—Locality TU 1375, Cercado Formation; Río Gurabo, 0.5 km south of mouth of Arroyo Palero; approximately 5 km (airline) upstream from ford on Los Quemados—Sabaneta road, Dominican Republic.

Material.—One specimen, the holotype.

Measurements.—USNM 416223 (holotype); length (incomplete) 15.6 mm, height (incomplete?) 19.4 mm, diameter (right valve) 8.7 mm (complete length probably ca. 17 mm, height ca. 19.6 mm); locality TU 1375.

Remarks.—A single anteroventrally incomplete right valve from the offshore facies of the Cercado Formation exposed in a long bluff on the west side of the Río Gurabo, approximately 0.5 km below the mouth of Arroyo Palero (locality TU 1375) differs so strikingly in its ornamentation, including the shape of the costae and the nature of the ornamental intritacalx as to merit inclusion in this report.

Comparisons.—As noted above, the shape of the costae and the interspaces, together with the unusual nature of the nodular intritacalx (Pl. 18, fig. 2), is wholly unlike that of any other species known.

Occurrence.—Cercado Formation: Río Gurabo (TU

1375).

Distribution.—Known only from the holotype specimen from the Cercado Formation, Dominican Republic.

Trigoniocardia (Trigoniocardia)
species aff. *T. (T.) maturensis* (Dall)

Plate 16, figures 5, 6

aff. *Cardium* (*Trigoniocardia*) *maturensis* Dall, 1900, p. 1105; Dall, 1903, pl. 48, fig. 7.

Description.—Shell ovate with high, slightly prosogyrate umbones and a moderately strong, non-angulate posterior umbonal ridge; surface ornamented with 18 or 19 radial ribs, eight on the posterior slope and 10 or 11 on the anterior slope; ribs tending to be broad, not strongly elevated above the relatively narrow interspaces that are crossed by strong transverse threads; interspaces between ribs adjacent to posterior ridge distinctly wider than those more distant in position. Intritacalx consisting of thin, rounded, smooth material with interspersed transverse nodules that, on the ribs adjacent to the umbonal ridge, extend across the rib-top but which become confined to the posterior half of the upper surface on the more anterior ribs; the absence of the smooth part of the intritacalx on the anterior side of these latter rib surfaces giving the appearance of the rib-top having an anterior slope; ribs on the posterior area of the valve narrower than those more anterior, and tending to have the nodes centrally positioned on their crests.

Material.—Fifteen specimens from four localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
NMB G 16955	9.0	13.8	4.7*	NMB 16835
NMB G 16956	8.5	10.4	4.0*	NMB 16837
PRI 33065	7.5	10.2	7.9*	NMB 16837

* left valve

Remarks.—*Cardium* (*Trigoniocardia*) *maturensis* Dall, 1900, was described on the basis of what, apparently, is an immature specimen, as follows:

Shell small, obovate, not carinate, short, elevated, somewhat oblique; posterior area with eight or nine ribs, body with twelve or thirteen; ribs rounded, low, those before the middle having a long slope anteriorly and a row of very small, bead-like nodules near the summit which is close to the short slope; all the ribs have this disproportionately small nodulation; the interspaces are narrow but not channelled, at the bottom is a cross-striation in arcuate lines; beaks not elevated for this group, shell with no sharp angles anywhere. Lon. 6.6, alt. 9, diam. 7 mm. (Dall, 1900, p. 1105)

This specimen, which was figured by Dall (1903, pl. 48, fig. 7), was listed as the "holotype" by Schuchert et al. (1905, p. 130; USNM 115665).

Jung (1969, p. 365, pl. 25, figs. 1–10) has listed and figured specimens from the type locality of the upper

Miocene Melajo Clay Member of the Springvale Formation, the lower Pliocene Courbaril Sand and Clay Member of the Morne l'Enfer Formation, and the Matura Sand and Clay Member of the Talparo Formation. On the basis of this material he cites the number of ribs as "about 20 . . . (average 19)", of which eight are on the posterior slope. Of the 16 valves in the present collection, eight have 10 and eight have 11 ribs on the anterior surface, with 15 having eight ribs and one with seven on the posterior slope. Since Dall's specimens, which had 20 to 21 ribs, came from the youngest of the three units from which the species is cited by Jung, it is possible that those from the Melajo Clay had a rib count similar to that of our specimens, thus resulting in his statement that the "average" was 19.

There is much variation in the relative strength of the nodules present on the intritacalx, some being relatively broad and subrounded, others narrow and almost threadlike; none, however, seem as high and closely approximate as those figured by Jung (1969, pl. 25, fig. 8) in the specimen from the Melajo Clay. For this reason the Dominican shells are only tentatively referred to this species.

Comparisons.—The Dominican form herein tentatively referred to *T. maturensis* is similar to that species as illustrated by Jung (1969, pl. 25, figs. 1–10), in having the same number of costae that appear to be of similar shape with similar intercostal areas and adorned by an intritacalx that appears to agree with that shown in the Jung figures. The present specimens differ, however, from those from Trinidad in being proportionately longer relative to valve height, especially on the dorsal part with, consequently, a longer hingeline, and also with a less steeply sloping posterior side.

This species was originally referred by Guppy (1867, p. 163; 1874, p. 442) to *Cardium haitense* Sowerby, 1850, which species may easily be distinguished by its larger size, more numerous radial costae, and generally more quadrate outline.

Occurrence.—Cercado/Gurabo formations: Río Cana (NMB 16834–16837, 16842).

Distribution.—Gurabo and uppermost Cercado formations, Dominican Republic. Described from Matura, Trinidad, the species has been previously reported only from the late Miocene and early Pliocene formations of Trinidad.

Trigoniocardia (Trigoniocardia) aminensis (Dall)

Plate 16, figures 9–12; Plate 18, figure 6

Cardium (Trigoniocardia) aminense Dall, 1900, p. 1104; Dall, 1903, pl. 48, fig. 11; Maury, 1917, p. 376.

Cardium aminense Dall. Maury, 1920, p. 35; Woodring, 1925, p. 144.

NOT *Cardium (Trigoniocardia) aminense* Dall. Vaughan *et al.*, 1921,

p. 146 [see discussion under *T. (T.) haitensis cercadica* (Maury) p. 114 herein].

Trigoniocardia aminense (Dall). Weisbord, 1964, p. 260; Jung, 1965, p. 454.

NOT *Trigoniocardia (Apiocardia) aminensis* (Dall). Woodring, 1982, p. 643, pl. 14 [114], figs. 3–5, 9 [fig. 8 is of Dall's Dominican type].

Description.—

Shell elongate, narrow, very convex; beaks high and narrow; body with ten or eleven high flat ribs, the margins overhanging the narrower cross-threaded channels; truncation with ten lower and narrower but very similar riblets; when perfect the ribs carry a series of, on the body, transverse wedge-shaped nodules with the long slope of the wedge pointing downward; the nodules on the truncation are smaller and connected, resembling a string of tear-shaped beads with the small end of the drop upward; internal margin with rather long flutings, hinge normal, shell rather thick. (Dall, 1900, p. 1104)

Holotype.—USNM 113800.

Type locality.—Locality TU 1364 (here restricted), Baitoa Formation; Boca de los Ríos, below the waterfall in Arroyo Hondo, which enters Río Yaque del Norte from the east, just below the confluence with the Río Bao, downstream from Baitoa, Dominican Republic.

Material.—A total of 144 valves from 12 localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
USNM 113800 ¹	10.0	13.8	6.2 ²	TU 1364 (see above)
USNM 416224	6.6	9.4	4.0 ²	TU 1364
USNM 416225	8.2	10.5	4.5 ³	TU 1364
USNM 416226 ⁴	13.9	20.0 ³	8.4 ²	TU 1364
PRI 33066	10.0	13.2	5.7 ²	TU 1364

¹ holotype; ² left valve; ³ right valve; ⁴ largest specimen in collections;

⁵ slightly incomplete

Remarks.—It seems certain that Dall had erroneous locality data for the collection from which came the type of *T. (T.) aminensis*. The extensive TU collections from Potrero on the Río Amina (locs. TU 1219, 1220) contain no specimens identifiable as this species. Collections from the lower Miocene Baitoa Formation, on the other hand, include approximately 150 valves that clearly are identical with the Dall species, the type specimen of which has, internally, a concretionary mass of rust-colored, moderately coarse-grained sediment that is exactly matched by similar material in specimens from that area in both the NMB and TU collections. This assignment to the Baitoa Formation is further supported by E. H. Vokes' recognition of a muricid specimen in the USNM collections said to have been from Potrero, but which, in every way, is identical with specimens from the Baitoa Formation in the Arroyo Hondo area. It bears the number USNM 113775, which is close enough to the 113800 number on the Dall type to suggest that both came from the same mislabelled collection.

Trigoniocardia (Trigoniocardia) aminensis does not

occur in any of the collections from the Gurabo Formation available for the present study. Examination of the specimens from that formation listed as *C. (T.) aminense* Dall by Vaughan and Woodring (*in* Vaughan *et al.*, 1921, p. 145) reveals that all are referable to *T. (T.) haitiensis cercadica* (Maury, 1917). As Woodring (1982, p. 643) noted, concerning those specimens, which he continued to refer to *T. aminensis*: "The ribs of the type are higher than those of the others in the Dominican Republic, . . . and slightly overhanging, and the interribs in front of the angulation on the type are slightly wider."

In his description, Dall stated that there were 10 or 11 high ribs on the anterior part of the shell with 10 on the posterior truncation. A count of the ribs on 100 of the valves in the present collections is shown in Table 7.

Table 7.—Numbers of ribs anterior and posterior to posteroventral angulation in 100 valves of *Trigoniocardia (Trigoniocardia) aminensis* (Dall).

	anterior				posterior		
	10	11	12	13	9	10	11
number of specimens	1	18	62	19	24	75	1

It is to be noted that the angulation between the anterior and posterior segments is marked, on the left valve, by a very strong and high rib that articulates marginally between two ribs on the right valve, which, although somewhat narrower and less pronounced, have the shape and ornamentation of the others on the anterior segment. However, the posterior of these two ribs is immediately adjacent to the other ribs on the truncation and might well have been considered as being a part of that ornament; in the present count this rib was considered, on the basis of its shape and ornamentation, as being a part of the anterior group.

The intritacalx on the ribs consists of somewhat swollen, transverse nodules separated by smooth interareas. The nodes completely cross the rib on earlier stages of growth but, on the left valves, tend gradually to be restricted to the posterior one-half or two-thirds of the width. This is particularly marked on the high, strong rib at the angulation. The few large right valves on which the intritacalx is still present suggest that the nodes remain wholly transverse at all stages. The interrib areas are marked by narrow, raised threads that may, or may not, parallel the growth lines and commonly are variable in direction on the same specimen (see Pl. 18, fig. 6).

The specimens from the Gatun Formation, Panama, identified by Woodring (1982, p. 643, pl. 114, figs. 3–5, 9; fig. 8 is of Dall's Dominican type) as *Trigoniocardia (Apiocardia) aminensis* (Dall), do not represent this species. Woodring apparently was misled, in part,

by his belief that *T. aminensis* was a species of the late Miocene/Pliocene Gurabo fauna. The Baitoa Formation being older than the Gatun, it would seem logical to believe that the more similar "narrow form" would occur in the lower part of that formation and the "relatively wide form that has subdued angulation" would have evolved later; however, the reverse is the case, the wide form being "the prevalent form in the lower part . . . whereas all except one of about 100 from the middle part represent the narrow form." Furthermore the number of ribs varies from "17 to 25, . . . 10 to 16 (generally 11 to 13) in front of the angulation, 6 to 10 (generally 8) on posterior slope" (Woodring, 1982, p. 643). None of the ribs immediately adjacent to the posteroventral angulation on the more than 300 valves from the lower part of the Gatun Formation in the TU collections show the relative difference in strength between the right and left valves that is so prominent a feature of the Baitoa specimens.

Comparisons.—In general appearance *T. (T.) aminensis* resembles some forms of the Trinidad species *T. maturensis* (Dall, 1900) (compare Pl. 16, fig. 9, with Jung's 1969, pl. 25, fig. 8), but the former differs in possessing a more angulate posteroventral umbonal ridge, resulting in more sharply angulate posteroventral and posterodorsal margins; the number of costae is said to average 19 on *T. maturensis*, whereas, on *T. aminensis* the average is 22, and the intritacalx on our Dominican specimens has narrower, more elongate transverse nodes.

Trigoniocardia simrothi (Dall, 1900) [p. 1104; Dall, 1903, pl. 48, fig. 8—see H. E. Vokes, 1977, p. 180, pl. 6, fig. 1; pl. 7, figs. 5–8] from the Chipola Formation of Florida, of Burdigalian, early Miocene age, is a smaller, proportionately more broadly quadrate form that also has an average of about 22 radial costae on which, however, the nodes of the intritacalx occur only on approximately one-half of the rib width, rather than being completely transverse.

Occurrence.—Baitoa Formation: Baitoa area (NMB 16935, 16936, 16938, 16942, 17283, 17284, 17288–17290; TU 1226, 1363, 1364).

Distribution.—Known only from the Baitoa Formation, Dominican Republic.

Subgenus GONICARDIA Woodring, 1982

Gonicardia Woodring, 1982, p. 644.

Type species.—*Cardium (Fragum) callopleurum* Gabb, 1881b, by original designation; Moín Formation, Pleistocene, Costa Rica.

Diagnosis.—Characterized by the possession of strong inverted V-shaped ribs of which the anterior side of those on the median portion of the valve has a more gentle slope than the posterior one. The intri-

taxal is marked by relatively abundant, small nodules that project from the crests of the ribs.

Remarks.—*Goniocardia* was proposed by Woodring for the type species and *Trigoniocardia melajoensis* Jung, 1969, from Trinidad. Examination of numerous specimens of *Cardium* (*Trigoniocardia*) *heredium* Olsson, 1922 [p. 227, pl. 27, fig. 10], from the Río Banano Formation ("Gatun stage" of Olsson) of Costa Rica, clearly indicates that it also is to be assigned to this subgenus.

The illustrations and description of *Cardium* (*Trigoniocardia*) *deadenense* Mansfield, 1932 [p. 113, pl. 22, figs. 2–5], from the Pliocene Choctawhatchee Group of Florida, strongly suggest its inclusion in this subgenus also, but no specimens were available for study.

***Trigoniocardia* (*Goniocardia*) *melajoensis* Jung**
Plate 16, figures 7, 8

Trigoniocardia (*Trigoniocardia*) *melajoensis* Jung, 1969, p. 366, pl. 25, figs. 11, 12.

Description.—

Shell small, subrhomboidal. Posterior umbonal angulation pronounced. Sculpture consists of 18–20 ribs. Posterior slope mostly with seven low, flat ribs sometimes carrying beads; their interspaces narrow. Central part of shell disc covered by three or four much stronger, elevated ribs with interspaces which are narrow at the bottom and crossed by concentric threads. Their cross section is triangular, and their crest is usually ornamented with beads. The anterior ones of these ribs become asymmetrically triangular in cross section with the steeper slope posteriorly. Toward the anterior slope the ribs become lower and flatter carrying transverse beads. Hinge normal. Inner margin strongly fluted. (Jung, 1969, pp. 366–367)

Holotype.—USNM 645354.

Type locality.—Locality USGS 18411; Melajo Clay Member, Springvale Formation; Mio-Pliocene, Trinidad.

Material.—A total of 188 valves from five localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
USNM 645354 ¹	10.0 ²	10.6 ²	?	(see above)
NMB G 16957	12.2	13.7	6.0 ³	NMB 15920
NMB G 16958	11.5	11.9	4.4 ³	NMB 15920
PRI 33067	10.2	11.7	4.1 ²	NMB 15920

¹ holotype; ² left valve; ³ right valve

Remarks.—Species referable to the subgenus *Goniocardia* appear to have been residents of very shallow-water environments. The present species, originally described from the basal unit of the Melajo Clay Member, Springvale Formation, occurs in the Dominican collections only from the most upstream outcrops of the Cercado Formation on the Río Gurabo and Río Cana that, in view of the depositional sequence in the area, are the most shallow-water deposits preserved. The specimens in the collections from locality TU 1301 on the Río Cana are associated with such typically

shallow-water forms as *Donax* Linnaeus, 1758, and *Anadara* (*Grandiarca*) *patricia* (Sowerby, 1850).⁴

Comparisons.—A count of the ribs on 50 valves of *T. melajoensis* from locality NMB 15920 shows a variation in number from 18 to 21, with three having 18 ribs, 24 with 19 ribs, 22 with 20 ribs, and but one with 21 ribs; 40% of the valves have seven ribs on the posterior area with the remaining 60% having eight. *Trigoniocardia heredia* (Olsson, 1922) from the Pliocene of Costa Rica, which is a similar appearing form, reveals a rib count varying between 17 and 20; two valves having 17 ribs, 10 with 18 ribs, 24 with 19 ribs, and 14 with 10 ribs; 24% of the valves have seven ribs posteriorly, 64% have eight, and 8% have nine. The more obvious difference in the ribbing is that the radials on the median area of *T. heredia* are relatively broader, with interspaces approximately two-thirds the width of those on *T. melajoensis*; the crestal intritacal nodes on the ribs are noticeably smaller and more numerous.

Similar differences distinguish *Trigoniocardia callopleurum* (Gabb, 1881b) [p. 375, pl. 47, fig. 77] which, on the basis of examination of the few topotype specimens in the TU collection (loc. TU 953; Moín Formation, Pleistocene, Costa Rica), appears to be a probable senior synonym of *T. heredia*. Gabb's type specimen is, however, much larger than any of the valves of *T. heredia*—or any other species of the subgenus in the available collections or reported in the literature; it is described as: "Length 0.9 inch; width 0.75 inch". Examination of the illustration clearly indicates that Gabb's "length" is the dimension that is here considered to represent the height of the valve, and "width" is the length; thus, in present terms the valve has a length of about 18.3 mm, and a height of 23 mm.

Occurrence.—Cercado Formation: Río Cana (TU 1301); Río Gurabo (NMB 15918, 15920, 15921, 15924, 15927).

Distribution.—Shallow-water facies of the Cercado Formation, Dominican Republic. Melajo Clay and Savaneta Glauconitic Sandstone members of Springvale Formation, Mio-Pliocene, Trinidad.

Genus AMERICARDIA Stewart, 1930

Americardia Stewart, 1930, p. 267.

⁴A similar shallow-water faunal association, including *A. patricia*, occurs at locality TU 1241 at Quebrada Chocolate in the Pliocene Río Banano Formation of Costa Rica, where *Trigoniocardia* (*Goniocardia*) *heredia* (Olsson, 1922) [p. 399, pl. 27, fig. 10] is an abundant element in the fauna. Olsson, who apparently did not collect from the Quebrada Chocolate area, which lies southwest of Puerto Limón, does not mention *A. patricia* in his report (1922), and the present record appears to be the first report of the presence of the Dominican *Anadara* (*Grandiarca*) *patricia* in the Costa Rican fauna.

Type species.—*Cardium medium* Linnaeus, 1758, by original designation; Recent, North Carolina to Brazil.

Diagnosis.—Quadrate cardiids with strong postero-umbonal keel setting off the posterior slope of valves and forming an angulate posteroventral margin; costae with intritacalx of closely approximate arched concentric threads on dorsal surface, which usually show a marked diversity of size, one or two stronger ones simulating transverse nodes and separating groups of numerous smaller ones; when intritacalx is removed by weathering, ribs have a smooth surface.

Remarks.—Stewart originally assigned *Americardia*, "perhaps arbitrarily" (1930, p. 268), to a position as a subgenus of *Trigoniocardia*. The hinge differs, however, in that the anterior laterals are almost as distant from the median cardinals as are the posterior ones, whereas in *Trigoniocardia* they are much closer to the cardinals than are the posterior ones. Furthermore, the great difference in the nature of the intritacalx, or deciduous outer layer (see H. E. Vokes, 1977, pp. 177–178), also seems to justify considering *Americardia* to be a completely separate generic lineage.

Americardia media (Linnaeus)

Plate 14, figure 14; Plate 19, figure 7

Cardium medium Linnaeus, 1758, p. 678; Gabb, 1881b, p. 374.

Cardium venustum Dunker, 1861, p. 37.

Cardium (Fragium) medium Linnaeus. Vaughan *et al.*, 1921, pp. 145, 168; Olsson, 1922, p. 398, pl. (27)30, fig. 6; Woodring, 1925, p. 140, pl. 19, figs. 5, 6.

Trigoniocardia (Americardia) medium (Linnaeus). Clench and Smith, 1944, p. 21, pl. 11, figs. 1, 2.

Trigoniocardia (Americardia) media Weisbord, 1964, p. 265, pl. 36, figs. 7–12 (see this for other Recent and Pleistocene references); H. E. Vokes, 1977, p. 178, pl. 6, fig. 2.

Americardia media (Linnaeus). Rios, 1985, p. 241, pl. 85, fig. 1201.

C. testa subcordata subangulata; valvulis angulatis sulcatis laevibus *Testa simillima priori* [*Cardium hemicardium*], *sed exalbido purpurascens varia, sulcis laevibus absque aculeis, angulisque obsoletis*. (Linnaeus, 1758, p. 678)

Description.—Shell inflated, inequilateral, squarely cordate with rounded anterior margin flattened ventrally up to a strong posteroventral angulation, above which the posterior margin is almost straight but with a tendency toward a median concavity, the depth of which is variable but commonly shallow; umbones inflated, prominent; ornamentation of radial ribs varying from 32 to 39 in number, commonly 36 or 37 in Recent specimens but tending to be somewhat more numerous in the fossil ones; ribs anterior to the postero-umbonal angulation strong and regular with deep and narrower interspaces, those on posterior slope, usually nine to 12 in number, the three or four most posterior, near the dorsal margin, being broad and somewhat rounded in section, the three or four ventral to them at the point of the sulcation that marks the

marginal concavity being narrower and somewhat lower than the rest; surface of the ribs in unworn specimens marked by a well-developed intritacalx, consisting of numerous close concentric threads that are arched on the tops of the ribs where every sixth or seventh, or up to ninth and tenth, thread becomes broader and higher than the intervening ones, simulating transverse nodes; the interspaces between the ribs are more finely cross-striated with commonly two or three threads uniting on the side of the rib to form those on the crest (see Pl. 19, fig. 7). Recent specimens white, clouded and spotted with reddish brown.

Holotype.—In collections of Linnaean Society of London (see Hanley, 1855, p. 47; Dodge, 1952, p. 56) with Linnaean No. 61.

Type locality.—Recent; Habana, Cuba (restricted by McLean, 1939, p. 167).

Material.—Forty-eight left and 31 right valves from five localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
USNM 416212	20.6	22.3	10.0 ¹	TU 1281
PRI 33068	16.7	17.7	7.3 ²	TU 1281

¹ left valve; ² right valve

Remarks.—*Americardia media* (Linnaeus, 1758) is a shallow-water species. The depth range is usually cited as being from "2 to 100 fathoms" (3.6 to 183 m) but all of the deeper-water records I have been able to check refer to separate valves rather than living individuals. This appears to explain the nature of its occurrence in the Gurabo Formation. The TU collections contain 63 small valves (the largest being 7.5 mm in height) from locality TU 1227A, a turbidity flow of shallow-water material, having a lenticular outcrop with a maximum height of approximately 25–30 cm and a total length of about 1 m; the three valves in the NMB collections are all small, the largest having a height of 9.3 mm, and come from an area on the Río Gurabo where such flows are known to be present in the outcrop section. There are also two larger valves from locality TU 1250, also from a turbidity flow.

The material from locality TU 1281, questionably referred to the Mao Adentro Member of the Mao Formation, reveals a much more shallow-water fauna than that of the typical Mao, including numerous specimens of *Strombus pugilis* Linnaeus, 1758, *Cerithium eburneum* forma *lymani* (Pilsbry, 1949), and *Bulla striata* Bruguière, 1792a, all species that live in depths of about 10 m or less. Our collections from this locality contain six valves of *A. media*. Through time there is a tendency in *A. media* toward a reduction in the number of radial ribs. The number counted on Recent specimens varies from 32 to 39, with the majority falling in the 35–37 interval. Clench and Smith (1944, p. 21)

cite the number as 33 to 36. Fifteen of the Gurabo specimens showed a range varying from 38 to 42, with four having 39 ribs and six having 40. One of the six valves from locality TU 1281 (Pliocene) had 37 ribs, three had 38, and two had 39. Woodring (1925, p. 140) cites the number of ribs on the Bowden (basal Pleistocene) specimens as being 36 to 40, and the mean of specimens in the TU collection from the middle Pleistocene part of the Moín Formation of Costa Rica is 38. A count of the ribs on 50 adult individuals of the many specimens blown ashore by hurricane "Allen", in 1980, at Playa Las Salinas, southwestern Dominican Republic, is shown in Table 8. Of particular interest was the fact that of the nine paired-valve specimens, all had one more rib on the right valve than on the left one.

Comparisons.—The species most closely related to *A. media* is *A. columba* (Heilprin, 1886) [p. 93, pl. 9, fig. 26], from the late Pliocene Caloosahatchee Formation of southern Florida. As noted above, the number of costae on the Dominican fossil specimens, as well as on those from the Bowden Formation of Jamaica, tends to exceed those on the Recent specimens of *A. media*. In this feature it is equivalent to the number present on *A. columba*; however, none of the specimens in the present collection approach the deep "hollowing of the posterior face and the more pronounced carination of the umbonal slope", cited by Heilprin as the distinguishing features of his species.

Occurrence.—Gurabo Formation: Río Gurabo (NMB 15846, 16934); Santiago area (TU 1227A, 1250). Mao Formation (? Mao Adentro Member): Guayubin area (TU 1281).

Distribution.—Gurabo and Mao formations, Dominican Republic. North Carolina southward to Bahia and Trinidad Island, Brazil; Bermuda, Bahama Islands, West Indies and Gulf of Mexico, Costa Rica, Panama, and Venezuela; Pleistocene–Recent.

Americardia(?) *guppyi* (Thiele)

Plate 14, figures 12, 13; Plate 18, figure 1

Cardium guppyi Thiele, 1910, p. 129, pl. 9, figs. 25, 26.

Cardium (*Fragum*) *elattocostatum* Woodring, 1925, p. 141, pl. 19, fig. 7.

Trigoniocardia antillarum (d'Orbigny). McLean, 1939, p. 166, pl. 25, figs. 7, 8 (not of d'Orbigny in de la Sagra, 1842).

Trigoniocardia (*Trigoniocardia*) *antillarum* (d'Orbigny). Clench and Smith, 1944, p. 19, pl. 11, figs. 3, 4 (not of d'Orbigny in de la Sagra).

Americardia guppyi (Thiele). Abbott, 1958, p. 124, pl. 4, figs. O, Q; Rios, 1985, p. 241, pl. 85, fig. 1200.

Description.—Shell subquadrate to subcircular in outline with prominent, subcentral umbones; anterior and ventral margins broadly rounded except at posteroventral area where the margin is sharply rounded into the slightly convex posterior side that is delimited

Table 8.—Numbers of ribs on 50 adult specimens of *Americardia media* (Linnaeus) blown ashore by hurricane "Allen", in 1980, at Playa Las Salinas, southwestern Dominican Republic.

	33	34	35	36	37	38	39
number of specimens	3	6	4	14	17	4	2

by a moderately strong posteroventral umbonal angulation; surface with 26 to 30 radial ribs, of which eight to 10 are on the posterior slope; ribs commonly slightly round-topped and, on the median portion of the valve, separated by flat-bottomed interspaces of approximately the same width; the ribs on the anterior portion are approximately of the same width as those on the median area, but the interspaces tend to become progressively narrower anterodorsally; posterior area commonly having the first three or four ribs behind the postero-umbonal angulation distinctly narrower than those more posterodorsal in position and with the interspaces tending to be relatively narrow; interspaces marked by narrow transverse threads; intritacal on the rib-tops consisting of relatively prominent swollen transverse beads separated by narrow, closely spaced, arched concentric threads with the distance between the beads and, therefore, the number of intervening threads, varying even on the same and adjacent ribs. Hinge typical of the genus except that the anterior lateral tends to be somewhat closer to the median cardinals than in the type species, *A. media*; inner margins strongly serrated.

Type material.—Not found; "... 15 mm lang, fast 15 mm hoch, 11.5 mm breit" (Thiele, 1910, p. 130).

Type locality.—Recent; Barbados, British West Indies.

Material.—A total of 144 right valves and 134 left valves from eight localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
USNM 416210	12.0	11.9	4.5 ¹	TU 1446
USNM 416211	10.8	10.6	4.2 ²	TU 1281
PRI 33069	13.1	13.5	5.6 ²	TU 1447

¹ left valve; ² right valve

Remarks.—Insofar as I have been able to discover, the present record represents the oldest known occurrence of *Americardia guppyi* (Thiele). The more than 250 specimens in the collections from the lower, relatively shallow-water facies of the unnamed formation exposed along the upper reaches of the Río Yaque del Norte downstream from Baitoa, appear to differ slightly from the Recent ones in possessing 26 to 31 (81% have 29 or 30) radial ribs, whereas the Recent have 26 to 29, with "about 9 of the ribs on ... the posterior slope" (Clench and Smith, 1944, p. 20). In the present study, of the late Miocene specimens 41% have nine

posterior ribs, and 46% have 10. However, the specimens with the larger number show a tendency to have three narrow ribs on the median portion of that slope, rather than but two wider ones such as are present on the examples with 26 to 29 ribs in both the fossil and Recent forms. In contrast, 12 of the 13 valves from the younger beds of the Mao Formation have 28 radials and one has 29. All other features, including valve shape, hinge structure, rib and interspace size, as well as surface ornament including intritacalx nodes and internodal areas, are identical with those seen on the Recent forms. The reduction in the number of radial ribs is apparently an evolutionary feature that may have possible stratigraphic significance; but without additional intermediate collections this cannot be evaluated sufficiently enough to justify separation of the Mio-Pliocene specimens as a distinct subspecies at this time.

The Thiele description of *Cardium guppyi* seems to have been overlooked for many years. The first subsequent record of the name I have found is its erroneous listing as a synonym of *Trigoniocardia antillarum* d'Orbigny by McLean (1939). This lack of recognition of the Thiele description may explain Woodring's comparison of *Cardium (Fragum) elatocostatum* Woodring, 1925 [p. 141, pl. 19, fig. 7], from the Bowden Formation of Jamaica, solely with *Cardium (Fragum) burnsii* Dall, 1900 [p. 1101; Dall, 1903, pl. 48, fig. 15], from the Florida Miocene Chipola Formation. Specimens in the TU collection leave no doubt that the Bowden species is to be considered a synonym of *A. guppyi*.

Comparisons.—As Woodring observed (1925, p. 141), in his comparison of *C. elatocostatum* (= *guppyi*), this species is similar to *Cardium medium* Linnaeus, 1758, but "may readily be distinguished from small specimens of *C. medium* of the same size, as they are less inflated, less sharply ridged, and have lower umbos and fewer ribs." He also added that *C. elatocostatum* "closely resembles *C. burnsii* Dall, 1900, from the Chipola Formation of Florida, but has higher and narrower umbos, more rounded posterior ridge, fewer ribs, deeper interspaces and coarser concentric ribs in the interspaces."

Woodring, in his description, noted that the "ribs bear at relatively distant intervals transverse or rounded beads, between which may lie very fine concentric threads." This intritacalx (see Pl. 18, fig. 1) is quite different from the surface ornament of *Americardia media* (see Pl. 19, fig. 7), the type species of *Americardia*, in which the surface is crossed by fine transverse threads with coarser ridges, commonly paired, occurring at intervals separated by five or more of the slender threads. The intritacalx of *A. guppyi* is more like that of the Chipola species (?) *Trigoniocardia burnsii* (see

H. E. Vokes, 1977, pl. 6, fig. 2) on which, however, the transverse nodes are stronger and there is commonly but one thread between each pair of nodes. In *Trigoniocardia (Trigoniocardia)*, the nodes are separated by smooth rib-top intervals without any finer threads between them. This difference, plus the somewhat more quadrate outlines of both *A. guppyi* and *T. burnsii*, in contrast to the triangular shape of *Trigoniocardia* species, makes them appear to be almost intermediate between the latter and typical *Americardia*.

Occurrence.—Gurabo Formation: Santiago area (TU 1250, 1448). Unnamed formation: López area (NMB 17278; TU 1443–1447). Mao Formation (?Mao Adentro Member): Guayubin area (TU 1281).

Distribution.—Gurabo Formation and unnamed correlative beds on the Río Yaque del Norte; Mao Formation, Dominican Republic. Bowden Formation, Pleistocene, Jamaica. Florida Keys, Antilles, Honduras to northern Brazil; Recent.

Subfamily **PROTOCARDIINAE** Keen, 1951

Diagnosis.—

Shell rounded-quadrate in outline, nearly equilateral; radial ribs present in most; posterior slope usually more strongly ribbed than remainder of shell, ribs often spinose; ribs of central and anterior slopes, when present, fine and numerous; hinge line long, nearly straight to somewhat arched; cardinal teeth, especially anterior cardinals, well developed; anterior lateral strong (rarely wanting). (Keen, 1980, p. 12)

Genus **NEMOCARDIUM** Meek, 1876

Nemocardium Meek, 1876, p. 167.

Type species.—*Cardium semiasperum* Deshayes, 1858, by subsequent designation, Sacco, 1899; Eocene, Paris Basin, France.

Subgenus **MICROCARDIUM** Thiele, 1934

Microcardium Thiele, 1934, p. 878.

Type species.—*Cardium (Fulvia) peramabile* Dall, 1881, by subsequent designation, Keen, 1937; Recent, Gulf of Mexico and Caribbean Sea.

Diagnosis.—Thin-shelled roundly quadrate cardiids with many low radial ribs and with secondary concentric sculpture crossing the intercostal spaces and forming minute beads on rib-tops of anterior and central areas of valves.

Nemocardium (Microcardium) islahispaniolae
(Maury)

Plate 17, figure 1; Plate 19, figure 5

Protocardia islahispaniolae Maury, 1917, p. 378, pl. (36)62, fig. 11; Vaughan et al., 1921, p. 147; Olsson 1922, p. 401.

Protocardia (Nemocardium) islahispaniolae Maury. Woodring, 1925, p. 147.

Description.—

Shell markedly resembling the recent deep sea Antillean *P. peramabilis* Dall [1881] and, to a less degree, the allied Bowden *P. jamaicensis* Dall [1900]; but nearly twice the size of the first and four times that of the second, and more excavated posteriorly than either. Posterior sculpture extending over more than a third of the shell, terminated by a slightly thicker radiating riblet and consisting of very narrow riblets, three to every millimeter, alternating with wider interspaces which are either transversely or obliquely cross-banded with fine lamellae, those obliquely barred intervening between one or generally two straight-banded spaces. For a distance of about five millimeters from the posterior margin the riblets cease and the surface is smooth except for three rather distant impressed, punctate lines. Near the anterior border of the posterior sculpture several rows of very minute prickles remain, evidently the remnants of many which once ornamented the shell and have been abraded. The few which remain all arise from the obliquely-banded interspaces. The anterior central portion of the shell is sculptured with stronger radiating and feebler concentric threads. The latter gradually strengthen anteriorly, where they form a network with the radiating threads, every intersection being knotted. The shell is exceedingly thin and fragile and cannot be removed from the matrix to examine the interior. (Maury, 1917, pp. 378–379)

Holotype.—PRI 28996; “length 23, altitude 22, approximate semidiameter 7.5 mm” (Maury, 1917, p. 379).

Type locality.—Gurabo Formation; Zone B, Río Gurabo at Los Quemados (Maury, 1917, p. 379) = locality TU 1211 (here restricted).

Material.—Five left and seven right valve fragments from seven localities.

Measurements.—USNM 416227; length (incomplete) 24.2 mm, height (incomplete) 23.7 mm, diameter (right valve) 7.5 mm; locality TU 1206.

Remarks.—As noted by Maury in her description, this species has an exceedingly thin and fragile shell; the only relatively complete specimen in the present collections is the immature valve figured on Plate 17, figure 1; all other specimens consist either of internal molds with shell fragments attached, or of pieces of shell found free in the matrix. Dall (1886, p. 270) stated that *Microcardium peramabile*, the type species of the subgenus, “seems to live in from 50–125 fms., and in water at a temperature ranging from 40 to 80 Fahrenheit.” The occurrence of the specimens of *N. islahispaniolae* only in the deposits of the deeper-water facies of the Gurabo and the Mao formations would seem to indicate a similar depth range for that species.

Comparisons.—In her original description of *Protocardia islahispaniolae*, Maury (1917) compared it with *P. peramabilis* (Dall, 1881) and *P. jamaicensis* (Dall, 1900), noting that her species was larger than either of the latter two and differed from both in being “more excavated posteriorly”. *Nemocardium* (*Microcardium*) *transversum* Rehder and Abbott, 1951 [p. 56, pl. 9, figs. 9, 10], described from the Gulf of Mexico off the coast of Louisiana, is also a somewhat smaller

form with a more rounded posterior end, but has an almost identical type of ornamentation on the posterior area (see Pl. 17, fig. 2; Pl. 19, fig. 6). The specimen figured is from locality TU 977, from relatively deep-water material brought to the surface in a diapiric mud-lump (No. 90) off the mouth of South Pass of the Mississippi River, thus, it is essentially a topotypic specimen of *M. transversum*.

Olsson (1922, p. 401, pl. 27[30], fig. 13) noted that *Protocardia costaricensis*, while of comparable size, has a “smaller” [= more narrowly elongate] posterior area that is “more coarsely sculptured”.

Occurrence.—Gurabo Formation: Santiago area (TU 1206, 1227, 1403). Mao Formation: Río Gurabo (NMB 15823, 15827, 15828, 15832).

Distribution.—Gurabo and Mao formations, Dominican Republic.

Subgenus **LOPHOCARDIUM** Fischer, 1887

Lophocardium Fischer, 1887, p. 1087.

Type species.—*Cardium cumingii* Broderip, 1833, by monotypy; Recent, Acapulco, Mexico, to Panama and Colombia.

Diagnosis.—Thin-shelled, elongately subovate cardiids with submedian umbones; anterior side broadly rounded; posterior area set off by a raised postero-umbonal lamina, lower than anterior, tapering to small terminal gape; hinge without lateral teeth.

Remarks.—*Lophocardium* has been considered to be a paciphile genus (Woodring, 1982, p. 645), represented only by two living species in the Pacific faunas off the coast of Central America, with an ancestral fossil species in the Caribbean region, occurring in the Dominican Republic, Costa Rica, Panama, and Florida. However, the hinge of the fossil form identified as *Lophocardium gurabicum* (Maury) by Woodring (1982, p. 646, pl. 114, fig. 6) is considerably different from that of the Recent forms. The latter have a weak hinge with two small pointed cardinal teeth in the right valve and only one in the left, and lateral teeth are absent from both valves. In contrast, the hinge of the left valve of the fossil form is said by Woodring to have a strong anterior cardinal tooth and a minute posterior one, plus a relatively strong anterior lateral and a suppressed posterior one. The hinge of the right valve is unknown.

Although it is possible that the fossil form represents an ancestral stage in the evolution of the Recent Pacific species, which include the type of the subgenus, it may also be that the somewhat similar valve shape and surficial ornament represent an example of evolutionary parallelism rather than ancestral relationship.

Nemocardium (?**Lophocardium**) **gurabicum** (Maury)

Protocardia gurabica Maury, 1917, pp. 377, 440, pl. (36)62, fig. 10.

Protocardia (Lophocardium) gurabica Maury. Olsson, 1922, p. 401, pl. (27) 30, figs. 7-9.

Protocardia (Lophocardium) gurabica vauhaniana Mansfield, 1932, p. 115, pl. 24, fig. 2.

NOT *Lophocardium gurabicum* (Maury). Olsson, 1964, p. 58, pl. 6, fig. 3.

Lophocardium gurabicum (Maury). Woodring, 1982, p. 645, pl. 114, figs. 1, 2, 6.

Description.—Shell ovate, thin, fragile, inflated, a little longer than high with the slightly gaping posterior end more extended than the rounded anterior one; umbo high, projecting well above the dorsal hinge margin, and strongly inflated; lunule narrow, inflated; surface reticulately sculptured by fine concentric threads, stronger near anterior margin, crossed by weak radial ribbing, the ribs slightly more distant from each other than are the concentrics.

Holotype.—PRI 28995.

Type locality.—Cercado Formation; Zone G, Río Gurabo at Los Quemados (Maury, 1917, p. 378) = locality TU 1297 (here restricted).

Material.—One specimen, the holotype.

Measurements.—PRI 28995 (holotype); length 24 mm, height approximately 21 mm, diameter (left valve) 18 mm (*vide* Maury, 1917, p. 378).

Remarks.—As noted above, in the discussion of the subgenus *Lophocardium*, this species also has been reported from Costa Rica and Panama. Mansfield has described, as subspecies *vauhaniana*, a form from the "Choctawhatchee Formation" [= Red Bay Formation, Choctawhatchee Group; Zone N. 17, late Miocene] of Florida, said to be somewhat longer and less elevated than the Maury type, which, however, is laterally incomplete. Woodring (1982, p. 646) indicates that its shape is matched by some of the Gatun specimens of *Lophocardium gurabicum*.

The specimen from the Miocene at Súa, Ecuador, cited as *Lophocardium gurabicum* (Maury) by Olsson (1964, p. 58, pl. 6, fig. 3), although incomplete, differs greatly in the shape of the preserved portions; the umbo is narrower and more sharply rounded dorsally than that of the Dominican type specimen and the anterior(?) end is shorter, broader and not produced laterally.

Comparisons.—Lacking any comparative material for this species, I can do no better than to quote (with a few typographical errors corrected) Olsson's discussion of the species (1922, p. 402):

The *P. gurabica* was described by Dr. Maury from the Gurabo [*sic* = Cercado] formation of Santo Domingo, and compared by her with the Vicksburgian *P. diversa* Conrad, but it appears to me to be a typical *Lophocardium* and representing the first member of this interesting subgenus to be found in the fossil state. As her specimen is very fragmentary, I have redescribed the species from better preserved Panama and Costa Rican material. The posterior end is gaping and the internal mold shows no impression of lateral teeth along

the hinge margin. It approaches closely the *L. Annettae* Dall [1889b], dredged from 8 to 27 fathoms in the Gulf of California, except that it is proportionately longer and lacks the concentric wrinkles on its posterior area. The *L. Cumingi* Broderip [1833], the type of the subgenus, carries between its posterior area and the general surface of the shell, a thin radial lamina or crest, extending from the umbos to the ventral margin.

The fossil shell is extremely thin. It generally occurs simply as internal molds which may still retain a part of the shell or impression of its sculpture on its surface.

As Olsson observed, the holotype is an extremely fragile, fragmentary specimen. As that specimen has been figured already by Maury (1917, pl. 62, fig. 10), it was deemed prudent not to subject this unique example to any further damage by attempting another photograph.

Occurrence.—Cercado Formation: Río Gurabo, Zone G, Río Gurabo at Los Quemados (Maury, 1917, p. 378).

Distribution.—In the Dominican Republic known only from the incomplete, worn, and fragile holotype; no specimens in either the TU or NMB collections. Red Bay Formation, Choctawhatchee Group, Florida; late Miocene; Gatun Formation, Panama and Costa Rica; Pliocene.

Subfamily LAEVICARDIINAE Keen, 1936

Diagnosis.—

Shell outline elliptical-oblique; posterior slope smoother or less heavily ribbed than remainder of shell; posterior margin entire or slightly wavy but not notched at rib-ends (a few crenulations may be present within); ribs mostly weak or lightly incised; hinge line long, arched; anterior lateral tooth long, often blade-like. (Keen, 1980, p. 14)

Genus LAEVICARDIUM Swainson, 1840

Laevicardium Swainson, 1840, p. 373.

Type species.—*Cardium oblongum* "Chem." [= Gmelin, 1791], by subsequent designation, Stoliczka, 1871; Recent, Mediterranean and Adriatic Seas.

Diagnosis.—Shell more or less smooth in appearance, but commonly tending to show low radial costae beneath the surface, which serrate the ventral margins of the valve; those on the posterior area generally not as submerged as are the more anterior ones. Hingeline arched with lateral teeth relatively large and prominent, cardinals small and subequal in size.

Remarks.—Swainson's original description, "shell longitudinally oval, inequilateral, the surface neither ribbed nor spined," together with the name proposed, suggests that both the name and the description may well have been based upon specimens of *Cardium laevigatum* Linnaeus, 1758, and indeed that species was the first to be designated subsequently as the type species by Herrmannsen (May, 1847, p. 571) and by Gray (November, 1847, p. 165). However, that species was

not listed by Swainson at the time of his description of his new "sub-genus", and the first valid designation appears to be that of Stoliczka, cited above. This is unfortunate as *Laevicardium oblongum* does not agree with the Swainson description in that it is characterized by low, round-topped radial ribbing over the central part of each valve, with the ribs on the posterior and anterior dorsal segments more or less submerged to the extent that these areas appear to be almost smooth.

Liocardium Agassiz, 1846 [pp. 119, 212] is an unnecessary emendation of *Laevicardium*.

***Laevicardium laevigatum* (Linnaeus)**

Plate 17, figures 3, 4

Cardium laevigatum Linnaeus, 1758, p. 680; Gmelin, 1791, p. 3251. *Cardium (Laevicardium) serratum* Linnaeus. Gabb, 1881b, p. 374; Dall, 1900, p. 1110 (in part, not including *Cardium venustum* Gabb); Brown and Pilsbry, 1911, p. 367; Maury, 1917, p. 376, in part, not pl. (36)62, fig. 8, pp. 424 *et seq.*; Maury, 1920, p. 36; Vaughan *et al.*, 1921, pp. 145, 161, 168; Pilsbry, 1922, p. 421; Maury, 1925b, p. 290; Woodring, 1925, p. 146; Anderson, 1929, p. 165; Mansfield, 1932, p. 114, pl. 23, fig. 7 (not of Linnaeus, 1758).

Cardium serratum Linnaeus. Olsson, 1922, p. 400, pl. 27(30), figs. 11, 12 (not of Linnaeus, 1758).

Laevicardium laevigatum (Linnaeus). Clench and Smith, 1944, p. 22, pl. 12, figs. 1–5; Macsotay I., 1968, pp. 58, 78; Woodring, 1982, p. 647, pl. 116, figs. 9, 17; Rios, 1985, p. 242, pl. 86, fig. 1205.

Laevicardium laevigatum laevigatum (Linnaeus). Olsson and Harbison, 1953, p. 105, pl. 11, figs. 5, 5a, 5b.

Laevicardium laevigatum wagnerianum Olsson and Harbison, 1953, p. 107, pl. 11, figs. 2, 2a.

Laevicardium cf. laevigatum (Linnaeus). Jung, 1969, p. 370.

Laevicardium (Laevicardium) laevigatum (Linnaeus). Perrillat, 1977, p. 32, pl. 17, figs. 7, 8; pl. 18, figs. 1–4.

Description.—Shell relatively thin and fragile, moderately inflated, obliquely subovate to subquadrate, being somewhat extended posteroventrally; anterior and ventral margins broadly and regularly rounded, curving rather sharply into the straight to slightly concave posterior end; dorsal margin arched, umbones subcentral, slightly prosogyrate, full and moderately high; a rounded posteroventral umbonal ridge present, more distinct on the umbonal area but becoming very broadly rounded toward valve margin; lunule lanceolate, of moderate width and defined by a shallow groove; lunular surface rising slightly toward the inner margin of the valve where it meets the dorsal side of the anterior portion of the hinge-plate, and, towards the posterior umbonal end, folding back to form a prominent secondary lunule-like structure; escutcheon not developed; anterior and posterior areas of valve surface smooth, the posterior portion delimited anteriorly by the umbonal ridge, the anterior one occupying approximately the dorsal third of the anterior slope; median surface with numerous, equally spaced, faint radial markings suggestive of radial ribbing submerged

beneath the smooth outer shell layer; surface also marked by fine concentric lines, most prominent umbonally; hinge-line arched, cardinal teeth small but well-developed, lateral teeth prominent and relatively large with the anterior tooth slightly nearer the cardinals than the posterior one; ligament external, long; adductor scars impressed, their dorsal ends adjacent to the distal third of the lateral teeth; inner ventral margin serrated by the subsurficial ribbing between the smooth anterior and posterior areas.

Type figure.—Chemnitz, 1782, pl. 18, fig. 189 (designated by Gmelin, 1791, p. 3251; see discussion in Clench and Smith, 1944, p. 23).

Type locality.—Recent; Matanzas Bay, Cuba (restricted by McLean, 1939, p. 169).

Material.—Thirty-one right and 19 left valves from 22 localities.

Measurements (in mm).—

specimen	length	height	diameter	locality
USNM 416229	22.6	24.5	9.1 ¹	TU 1294
NMB G 16959	22.6	22.5	9.1 ²	NMB 16924

¹ right valve; ² left valve

Remarks.—The extremely complicated problem as to the correct name to be applied to this species has been considered at some length by Dodge (1952, p. 63), who concluded that the solution proposed by Clench and Smith (1944, p. 23) was the most tenable, adding:

The allocation of the name *laevigatum* to the common egg-cockle of the western Atlantic, and of *serratum* to the eastern [Indo-Pacific] shell, is a useful and probably correct solution, but should be used with the reservation that it is to a certain extent arbitrary.

Laevicardium laevigatum (Linnaeus) is not a common species in the collections studied. Basically a shallow-water form, it occurs most often in the collections from the Cercado Formation. Of the 91 specimens in the TU and NMB collections, only three have paired valves suggestive of burial in life position; these come from the Cañada de Zamba area of the Río Cana drainage. All of the specimens are relatively small compared with the modern examples of the species. Clench and Smith (1944, p. 24), for example, cite a specimen from Ponce, Puerto Rico, with a height of 82 mm, and state that the average size of the Recent shells is: length 32, height 40, width 22.5 mm. The largest of our Dominican specimens has a length of 29.9 mm, and a height of 32.3 mm. The average length of the more adult specimens is about 20 mm, although 24 of the 91 are less than 5 mm in length. The fragile nature of the shell has resulted in the larger specimens commonly being broken and incomplete. The smaller ones that have survived reveal the characteristic tendency to be pro-

portionately somewhat more elongate relative to height, resulting in a more quadrate valve outline.

Comparisons.—There has been much uncertainty as to the nature of the shells to be referred to *Laevicardium laevigatum* (Linnaeus). The first ones to study the problem in detail appear to have been Clench and Smith (1944, pp. 22–25), who conclude that Gmelin (1791, p. 3251) fixed the type for the species through his reference to Chemnitz (1782, pl. 18, fig. 189). Examination of this illustration shows a large and well-rounded shell with strong ribbing (for the genus) on the medial area anterior to a smooth posterior segment and a relatively coarsely crenulate inner margin. The drawing does not permit any certain conclusion as to the anterior dorsal segment, but it appears also to have been smooth.

On the basis of this conclusion, *L. laevigatum* differs from *L. vitellinum* (Reeve) in being larger, more convex, with much stronger radial ribbing, and much more pronounced anterior and posterior non-ribbed areas. Olsson and Harbison (1953, p. 107) note that *L. vitellinum* is also marked by having, on the posterior dorsal area of the left valve, two or three elevated threads radiating from the umbones.

In the discussion of *L. venustum*, new name, it is observed the latter species has a more subtriangular outline than *L. laevigatum*, giving more sharply rounded anterior and posterior ends, with radial ribbing, though very weak, more pronounced on the anterior part of the medial area than on the posterior half, and, hence, a more strongly crenulate anterior segment of the ventral margin.

Occurrence.—Cercado Formation: Río Cana area (TU 1421; NMB 16835); Río Gurabo (TU 1358, 1375, 1377, 1378; NMB 15906); Río Mao (TU 1294, 1379; NMB 16912, 16917, 16923, 16924, 16929, 16932). Gurabo Formation: Río Cana area (TU 1354; NMB 16818, 16833); Río Amina area (TU 1219, 1371, 1455); Santiago area (TU 1404, 1455). Mao Formation: Río Gurabo (NMB 15823).

Distribution.—Cercado, Gurabo, and Mao formations, Dominican Republic. Mio-Pliocene: Puerto Rico, Lares and Quebradillas limestones; Trinidad, Springvale Formation and Courbaril Member, Morne l'Enfer Formation; Venezuela, Güiría Formation; Costa Rica, Río Banano Formation; Colombia, Tubará Group; Panama, La Boca, Alhajuela, and Gatun formations; Mexico, Santa Rosa beds; Florida, Choctawhatchee Group and Caloosahatchee Formation. Bermuda, North Carolina to both sides of Florida, Louisiana, Texas, Campeche Bank, Yucatan Peninsula, Central America, Greater Antilles, and West Indies to Santa Catarina, Brazil (Rios, 1985, p. 242); Pleistocene–Recent. (For a detailed listing of many Recent localities see Clench and Smith, 1944, p. 25).

Laevicardium vitellinum (Reeve)

Plate 17, figures 5–7

Cardium vitellinum Reeve, 1844, pl. 7, fig. 37; Reeve, 1845, p. 168.

Cardium (*Laevicardium*) *serratum* Linnaeus. Maury, 1917, p. 366, in part, pl. (36)62, fig. 8 (not of Linnaeus, 1758).

Laevicardium laevigatum (Linnaeus). Clench and Smith, 1944, p. 22 (in part).

Laevicardium vitellinum (Reeve). Olsson and Harbison, 1953, p. 107, pl. 11, figs. 2, 2a.

Description.—

Card. testa oblique ovata, tenuicula, radiatim striata; lutescente-alba, maculis parvis numerosis rosaceo-fuscescentibus umbones versus copiose lentiginosa, epidermide lutea induta; marginibus intus crenulatis.

THE EGG-YOLK COCKLE. Shell obliquely ovate, rather thin, radiately striated; yellowish white, copiously freckled with numerous small pinkish-brown spots, covered with a yellow epidermis; margins crenulated within. (Reeve, 1844, expl. to pl. 7)

Laevicardium vitellinum is usually much smaller [than *L. laevigatum* (Linnaeus, 1758)], less convex with narrower umbos, the ribbing finer, less evident, hence the crenulations of the ventral margin are weaker. Its dorsal areas are poorly defined, often obscure, that of the left valve having a double ray or pair of raised threads extending outward from the beak. (Olsson and Harbison, 1953, pp. 106–107)

Type specimen.—Cumming collection, *vide* Reeve; ? in British Museum (Natural History).

Type locality.—Unknown.

Material.—Three paired valve specimens, plus 19 left and 14 right valves — many uncomplete.

Measurements (in mm).—

specimen	length	height	diameter	locality
NMB G 16960	21.6	25.5	7.7 ¹	NMB 16837
NMB G 16961	22.7	26.7	17.0 ²	NMB 16818
USNM 416230	17.6	19.4	11.7 ²	TU 1354

¹ right valve; ² paired valves

Remarks.—The identification of the present form is based upon the figure and descriptive comparison with *L. laevigatum* given by Olsson and Harbison; Reeve's original description, cited above, is too generalized and his illustration inadequate to permit any certain assignment.

In the present collection *L. vitellinum* is clearly a more offshore, somewhat deeper-water species than typical *L. laevigatum*.

Comparisons.—In general, the shells of *L. vitellinum* are more produced posteroventrally in outline than those of *L. laevigatum* (although some specimens of *laevigatum* show a similar shape), are less inflated, and with finer, commonly indistinct radial ribbing, causing a less pronounced change from the medial ornamented area to the smooth lateral ones. However, the most distinctive character is the presence of the two or three radial ribs on the posterodorsal area of the left valve.

Occurrence.—Cercado Formation: Río Cana area (TU 1420; NMB 16837); Río Gurabo (NMB 15896). Gurabo Formation: Río Cana area (TU 1354, 1356; NMB 16814, 16818, 16825, 16831, 16866); Río Gurabo (NMB 15842); Río Mao area (TU 1225, 1293, 1409); Río Amina area (TU 1371); Santiago area (TU 1206, 1445).

Distribution.—Cercado and Gurabo formations, Dominican Republic. Otherwise not certainly known; it appears that most authors have tended to assign all larger specimens of *Laevicardium* to *L. laevigatum* (+ *serratum* of auct.). Olsson and Harbison (1953, p. 107) report a single specimen from the Caloosahatchee Formation, but figure (pl. 11, figs. 2, 2a) a Recent specimen from Tortola, Virgin Islands; however, in the TU collections the species is common at several Caloosahatchee localities.

Laevicardium venustum, new name

Plate 17, figures 8, 9

Cardium (*Laevicardium*) *venustum* Gabb, 1873, p. 251; Maury, 1917, pp. 377, 427, 429, pl. (36)62, fig. 9; Vaughan *et al.*, 1921, pp. 124, 129, 145; Pilsbry, 1922, p. 421, pl. 25, figs. 2, 7 (lectotype); Olsson, 1922, p. 400; Woodring, 1925, p. 145; Anderson, 1929, p. 166; Woodring, 1982, p. 646 (non *Cardium venustum* Dunker, 1861).

Cardium (*Laevicardium*) *serratum* Linnaeus. Dall, 1900, p. 1110 (in part, *C. venustum* Gabb listed as synonym); Dall, 1901, p. 387 (not of Linnaeus, 1758).

Cardium venustum Gabb. Clench and Smith, 1944, p. 32.

Etymology of name.—*L. venustum*, diminutive of *venustus* = beautiful.

Description.—

Shell oblique cordiform, convex; umbones larger; anterior end rounded; posterior obliquely produced; surface marked in the middle by very numerous minute radiating ribs; anterior and posterior ends smooth. Length about 1 inch.

Nearest to *C. oblongum*, but much shorter, more expanded posteriorly and with much finer ribs. (Gabb, 1873, p. 251)

The shell is longer than high, transversely oval, with very convex, but somewhat narrow and markedly prosogyrate beaks, which project far more above the hinge outline than *C. serratum* [= *C. laevigatum* Linnaeus, 1758]. The anterior and posterior areas are smooth, the median portion finely ribbed, the ribs low, flattened, much wider than the intervals, which are closely and finely striated transversely. There are about 50 ribs. The right anterior cardinal tooth is peglike, higher than the posterior. Lateral teeth compressed, the posterior, especially, much thinner than in *C. serratum* . . .

This species has been placed in the synonymy of *C. serratum*, but it seems to me distinct by the far larger beaks, of a different shape, and the differences in the teeth. In *C. serratum* the beaks are much wider and lower, even in specimens of far greater size. The sculpture described may possibly be due to disintegration of the outer layer, though we see no evidence that this is the case. (Pilsbry, 1922, pp. 421–422)

Holotype.—ANSP 2768; "length 33, alt. 31, diam. of one valve 13 mm" (Pilsbry, 1922, p. 422).

Type locality.—Locality TU 1359 (here restricted),

Cercado Formation; Río Gurabo, east side at long bluff that extends upstream from a point opposite the mouth of Arroyo Palero, approximately 5.5 km (airline) above the ford on the Los Quemados–Sabaneta road (= locs. NMB 15903, 15904), Dominican Republic. This locality is selected because 14 of the 38 specimens in the present collections are from this bluff, including most of the better preserved ones.

Material.—Seventeen right and 20 left valves from 20 localities, nearly all incomplete due to thin fragile shell.

Measurements (in mm).—

specimen	length	height	diameter	locality
NMB G 16962	33.8	31.5	10.9 ¹	NMB 16857
USNM 416231	39.0	38.7	12.8 ²	TU 1359

¹ left valve; ² right valve

Remarks.—*Laevicardium venustum* is essentially a member of the fauna of the Cercado facies. The present collection contains only one specimen from deposits of the Gurabo facies and that is from the Arroyo Zalaya, south of Santiago, in an area where the deep-water Gurabo beds contain several turbidity-flow lenses that bring sediments of the Cercado facies into the Gurabo (e.g., loc. TU 1227A). Vaughan *et al.* (1921, p. 145) also list it from their locality USGS 8519, which is the Bluff 1 of Maury (1917), stating that their collection was "mostly from the lower part of the bluff." The Bluff 1 locality is in the lower portion of the Gurabo section.

The species name *venustum*, proposed by Gabb, 1873, being preoccupied by *Cardium venustum* of Dunker, 1861, is here renamed *venustum* and assigned to the genus *Laevicardium*. Those few authors who have cited *C. venustum* Dunker have simply listed it in the synonymy of *Cardium medium* Linnaeus, 1758, type species of the genus *Americardia* Stewart, 1930.

Comparisons.—All subsequent authors who have considered the species have agreed that Dall (1900, p. 1110; 1901, p. 387) was in error when he relegated *Laevicardium venustum* (Gabb) to the synonymy of what is now known as *Laevicardium laevigatum* (Linnaeus). Comparison with Recent specimens of *L. laevigatum* reveals that *L. venustum* has a more subtriangular outline, with more sharply rounded anterior and posterior ends, a stronger and more pronounced postero-umbonal ridge, and a ventral margin that is finely serrated by the medial radial ribbing, the serrations being more pronounced on the anterior half of the area, reflecting the stronger radials present over that part of the exterior. The illustration of the exterior of the type given by Pilsbry (1922, pl. 25, fig. 2) compared with specimens of the present report suggests that the former has a somewhat abraded surface; in

unworn specimens the ribbing is scarcely visible except near the ventral portion of the anterior third and an extremely small posterior segment of the medial area.

Occurrence.—Cercado Formation: Río Cana area (TU 1421; NMB 16835, 16857); Río Gurabo (TU 1297, 1358, 1359, 1373, 1374, 1377, 1378; NMB 15880, 15903, 15904, 15906, 15910); Río Mao (TU 1379; NMB 16913, 16916). Gurabo Formation: Santiago area (TU 1227).

Distribution.—Cercado and Gurabo formations, Dominican Republic. Tubará Group, Pliocene, Colombia.

APPENDIX I

SPECIES NOT REFERABLE TO CARDIIDAE

Anodontia bulla (Gabb)

Cardium (*Serripes*) *bulla* Gabb, 1873, p. 251.

Lucina bulla (Gabb). Pilsbry, 1922, p. 417, pl. 46, fig. 6.

Description.—

Shell sub-circular, thin, compressed, umbones small, posterior side a little more produced than the anterior. Surface marked only by lines of growth. Diameter 1.7 inch.

Not unlike *C. (S.) Groenlandicum* [Bruguière, 1789], but flatter and more circular. (Gabb, 1873, p. 251)

The somewhat prosogyrate beaks are a little in front of the middle. There is an extremely narrow and small lunule. The surface is somewhat roughened by growth lines; on the posterior and anterior slopes the rugosity is greater. Posteriorly a few minute short wrinkles run more obliquely toward the basal margin. In suitable light, very weak traces of radial sculpture are discernable. It was probably very little alate in front of the beaks but the shell is broken away there . . .

The type is an excellent specimen except for some breakage of the anterior margin. The hinge is not visible, but the characters, so far as shown, are those of a Lucinid shell and not of a *Cardium*.

There is also a broken and distorted specimen. (Pilsbry, 1922, pp. 417–418)

Lectotype.—ANSP 2763 (selected by Pilsbry, 1922, p. 418); "length 44, alt. 40, diam. 23.7 mm" (Pilsbry, 1922, p. 418).

Type locality.—Locality TU 1443 (here restricted), unnamed formation; east bank of Río Yaque del Norte, below village of López, downstream from the junction of the Río Bao with the Río Yaque del Norte, Dominican Republic. Our collections from this area con-

tain a number of specimens of *Anodontia* and other lucinids with a matrix of similar color and sedimentary type to that present in the Gabb specimens.

Remarks.—The tray with the label stating "Type", catalogue number 2763, and the original identification: "*Cardium bulla* Gabb — Miocene — S. Domingo — W. M. Gabb" has the word *Cardium* crossed out, with the word *Lucina* printed above it in a very different style and ink. It contains two specimens, one of which is that described and figured by Pilsbry (1922, p. 419, pl. 46, fig. 6). The other, the "broken and distorted specimen" of Pilsbry's discussion, has been crushed ventrodorsally until it has a distinctly elongate shape that is somewhat similar to the shape of specimens of *Serripes groenlandicus* (Bruguière, 1789). It may have been the specimen referred to by Gabb, while that cited as type by Pilsbry may have been that listed by Gabb (1873, p. 251) as "*Loripes edentula*. Linn., Mus. Ulric. p. 74", a species not mentioned in the Pilsbry paper. However, comparison of the growth lines on the undistorted dorsal portion of the crushed specimen with those on the specimen cited as type by Pilsbry convinces me that Pilsbry was correct and the two are the same species.

APPENDIX II

SUPPLEMENTARY LOCALITY DATA

The following are Tulane University localities not in the Dominican Republic, which are cited in this paper:

TU 705.—Bowden Formation (type locality). Bowden, east of Port Morant, Parish of St. Thomas, Jamaica.

TU 953.—Moín Formation (type locality). Moín Hill, railroad cut and adjacent ditches on road to Sandoval, 4.5 km west of Puerto Limón, Costa Rica.

TU 958.—Gatun Formation. Hillslope on east side of road from Boyd-Roosevelt Highway to "Refinería Panamá, S. A.," about ½ km north of junction, just east of Cativá, Prov. of Colón, Panama.

TU 977.—Unnamed post-Pleistocene formation. Mud-lump No. 90, mouth of South Pass, Mississippi River delta, Louisiana.

TU 1241.—Rio Banano Formation. Quebrada Chocolate, 6.6 km west of junction of Costa Rica Highway 32 (to San Jose) and Aereo-puerto road, at southwest edge of Puerto Limón, Costa Rica.

TU 1430.—Gatun Formation. North side Boyd-Roosevelt Highway, approximately one km northeast of Coco Solo Hospital, Prov. of Colón, Panama.

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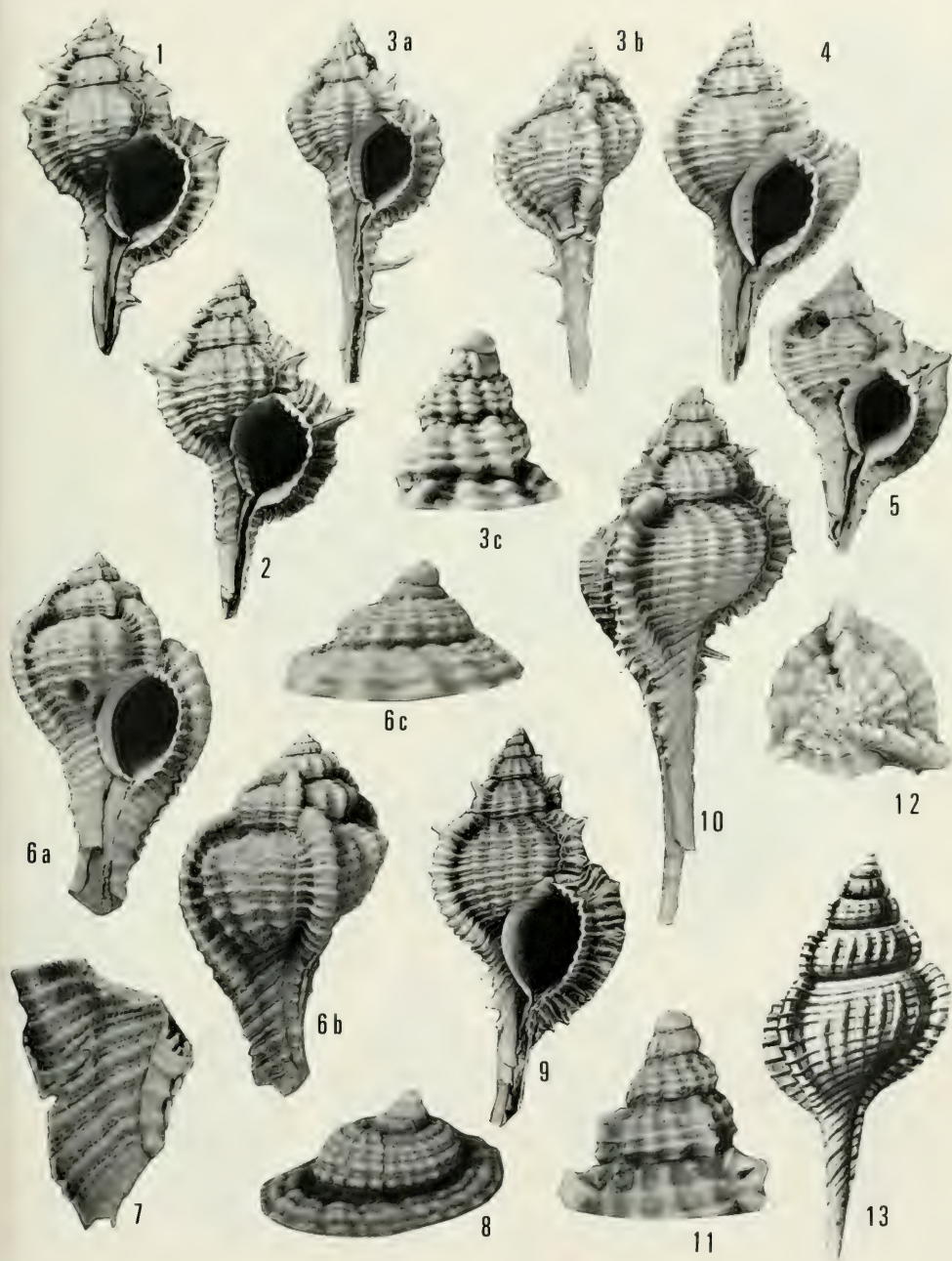
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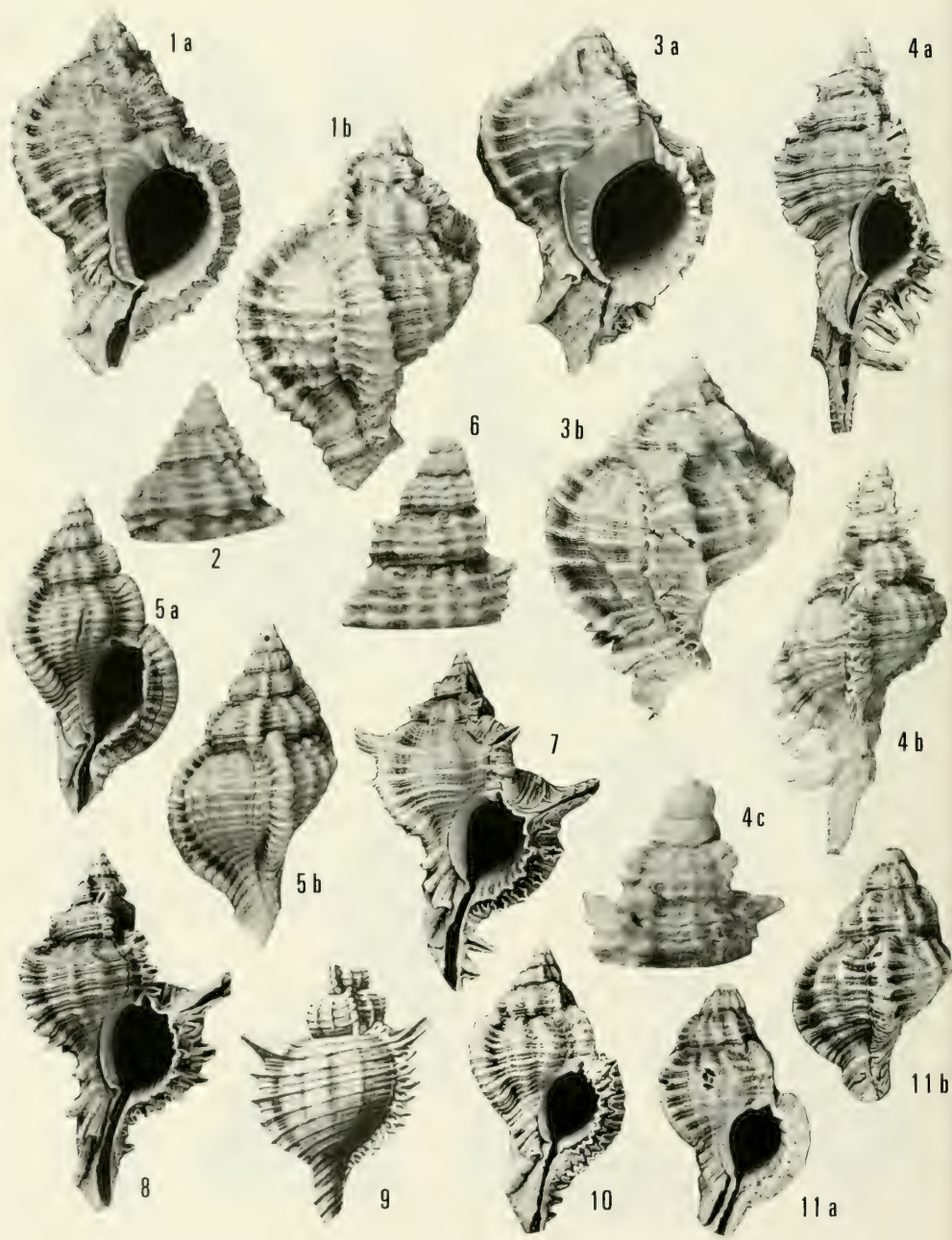
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Figure	Page
1-5. <i>Murex (Haustellum) messorius</i> Sowerby	25
1. Apertural view, USNM 323851 (hypotype), $\times 1\frac{1}{4}$. Río Mao, Cercado Formation, locality TU 1294. Height 49.2 mm, diameter 30.8 mm.	
2. Apertural view, USNM 323852 (hypotype), $\times 1\frac{1}{4}$. Río Gurabo, Gurabo Formation, locality TU 1215. Height 36.6 mm, diameter 21.6 mm.	
3. USNM 323853 (hypotype). Río Cana, Cercado Formation, locality TU 1230. Height 32.3 mm, diameter 13.7 mm. a. Apertural view, $\times 2$. b. Adapertural view, $\times 2$. c. Enlargement showing protoconch, $\times 10$.	
4. Apertural view, NMB H 17002 (hypotype), $\times 1\frac{1}{2}$. Río Yaque del Norte, unnamed formation, locality NMB 17273. Height 41.4 mm, diameter 22.0 mm.	
5. Apertural view, NMB H 16992 (hypotype), $\times 1\frac{1}{4}$. Río Gurabo, Mao Formation, locality NMB 15833. Height 42.4 mm, diameter 27.0 mm.	
6, 7. <i>Murex</i> (? <i>Haustellum</i>) <i>adelosus</i> , new species	30
6. NMB H 17000 (holotype). Cañada de Zamba, Río Cana area, Gurabo Formation, locality NMB 16818. Height 42.7 mm, diameter 24.4 mm. a. Apertural view, $\times 1\frac{1}{2}$. b. Adapertural view, $\times 1\frac{1}{2}$. c. Enlargement showing protoconch, $\times 10$.	
7. Adapertural view of siphonal canal, NMB H 17001 (paratype), $\times 2$. Cañada de Zamba, Río Cana area, Gurabo Formation, locality NMB 16818. Height (incomplete) 39.4 mm, diameter (incomplete) 23.0 mm.	
8. <i>Murex</i> (? <i>Haustellum</i>) species aff. <i>M. wilsoni</i> (D'Attilio and Old)	30
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9-13. <i>Murex (Haustellum) penna</i> Maury	27
9. Apertural view, USNM 323854 (hypotype), $\times 1\frac{1}{2}$. Río Amina, Gurabo Formation, locality TU 1219. Height 48.0 mm, diameter 23.1 mm.	
10. Adapertural view, USNM 323855 (hypotype), $\times 1\frac{1}{2}$. Río Mao, Gurabo Formation, locality TU 1293. Height 64.6 mm, diameter 28.6 mm.	
11. Enlargement showing protoconch, USNM 645428 (hypotype), $\times 10$. Río Mao, Gurabo Formation, locality TU 1293. Height 36.4 mm, diameter 16.5 mm.	
12. Posterior view, showing alignment of varices on spire, USNM 323856 (hypotype), $\times 1\frac{1}{2}$. Río Amina, Gurabo Formation, locality TU 1219. Height 42.4 mm, diameter 22.5 mm.	
13. Adapertural view, specimen from Maury (1925a, pl. 6, fig. 4), $\times 1\frac{1}{2}$. Río Pirabas, Pirabas Limestone, Pará, Brazil. Height 50 mm, diameter 20 mm.	



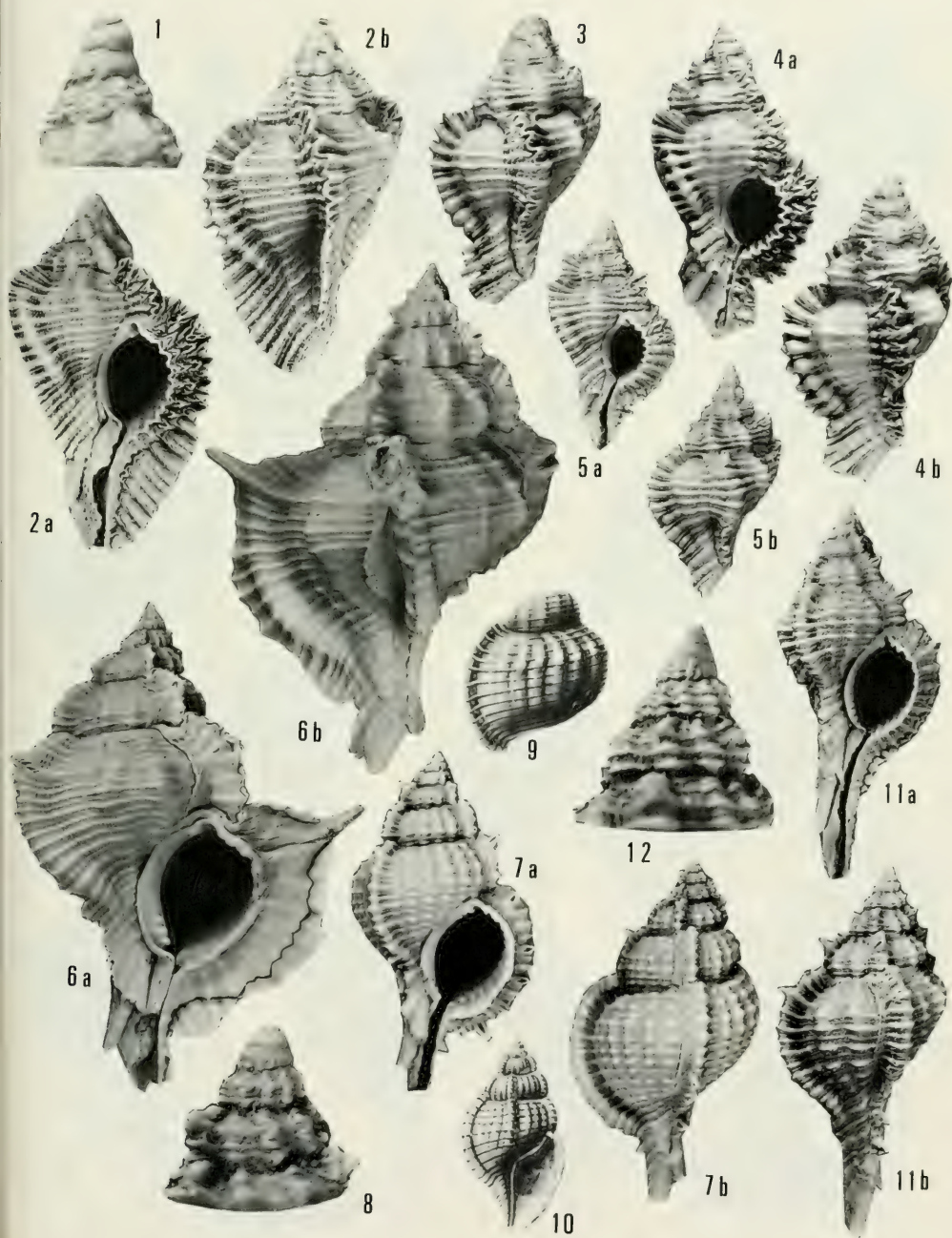


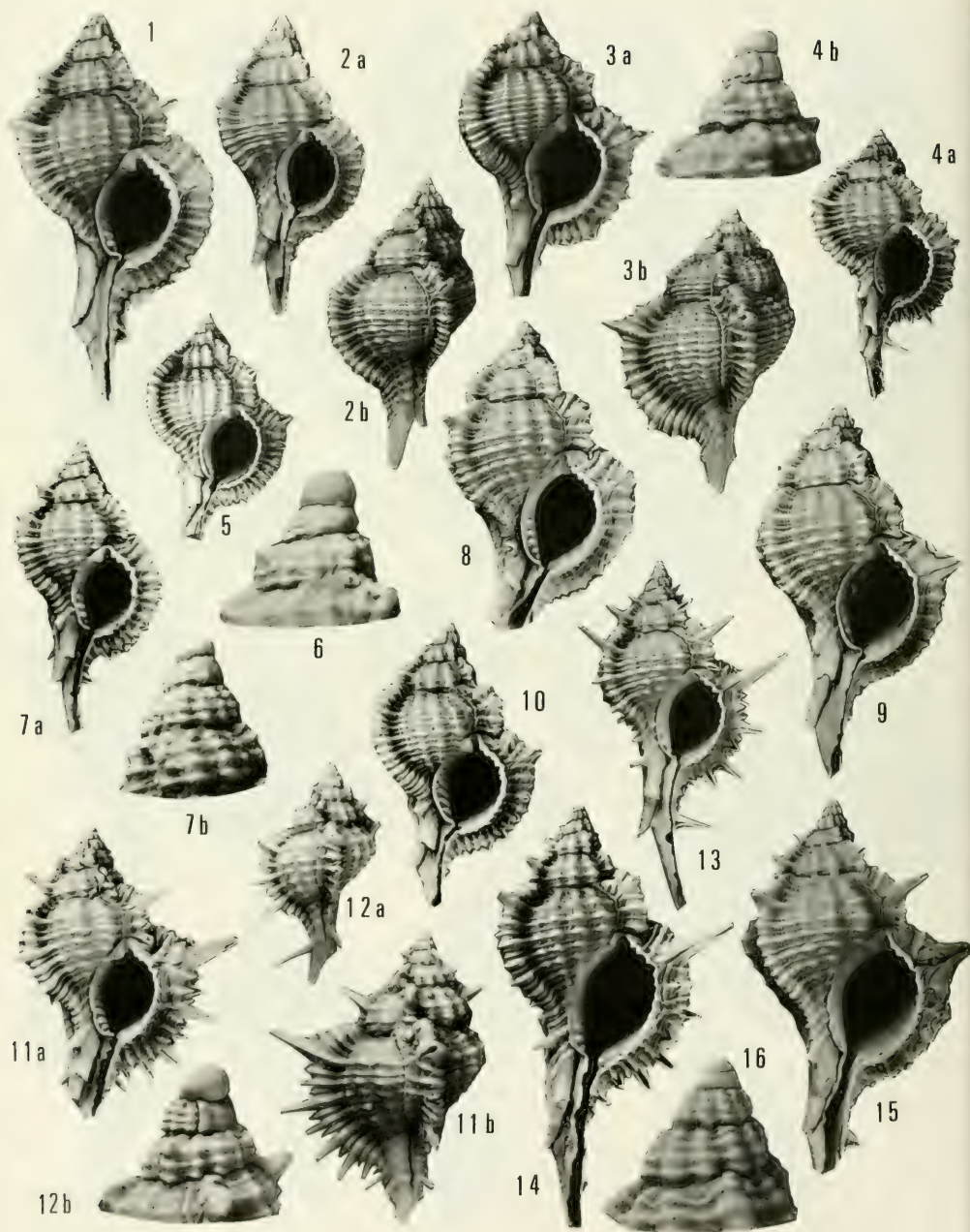
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1, 2.	<i>Chicoreus (Phyllonotus) pomatus</i> , new species	39
	1. USNM 323857 (holotype). Río Gurabo, Gurabo Formation, locality TU 1215. Height 52.8 mm, diameter 32.3 mm. a. Apertural view, $\times 1\frac{1}{4}$. b. Adapertural view, $\times 1\frac{1}{4}$.	
	2. Enlargement showing protoconch, USNM 323858 (paratype), $\times 10$. Arroyo Zalaya, Santiago area, Gurabo Formation, locality TU 1227A. Height 7.0 mm, diameter 3.7 mm.	
3.	<i>Chicoreus (Phyllonotus) pomum</i> (Gmelin)	40
	USNM 323859 (hypotype). Río Gurabo, Mao Formation, locality TU 1352. Height 65.0 mm, diameter 44.8 mm. a. Apertural view, $\times 1$. b. Adapertural view, $\times 1$.	
4.	<i>Chicoreus (Chicoreus) cosmani</i> Abbott and Finlay	35
	USNM 323863 (hypotype). Río Gurabo, Gurabo Formation, locality TU 1215. Height 28.5 mm, diameter 11.7 mm. a. Apertural view, $\times 2\frac{1}{2}$. b. Adapertural view, $\times 2\frac{1}{2}$. c. Enlargement showing protoconch, $\times 10$.	
5.	<i>Chicoreus (Phyllonotus) infrequens</i> (Vokes)	39
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6-9.	<i>Chicoreus (Chicoreus) cornurectus</i> (Guppy)	31
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	7. Apertural view, USNM 323861 (hypotype), $\times 1\frac{1}{2}$. Río Mao, Cercado Formation, locality TU 1294. Height 42.3 mm, diameter (excluding shoulder spines) 19.0 mm.	
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10, 11.	<i>Chicoreus (Chicoreus) dujardinoides</i> (Vokes)	33
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Figure		Page
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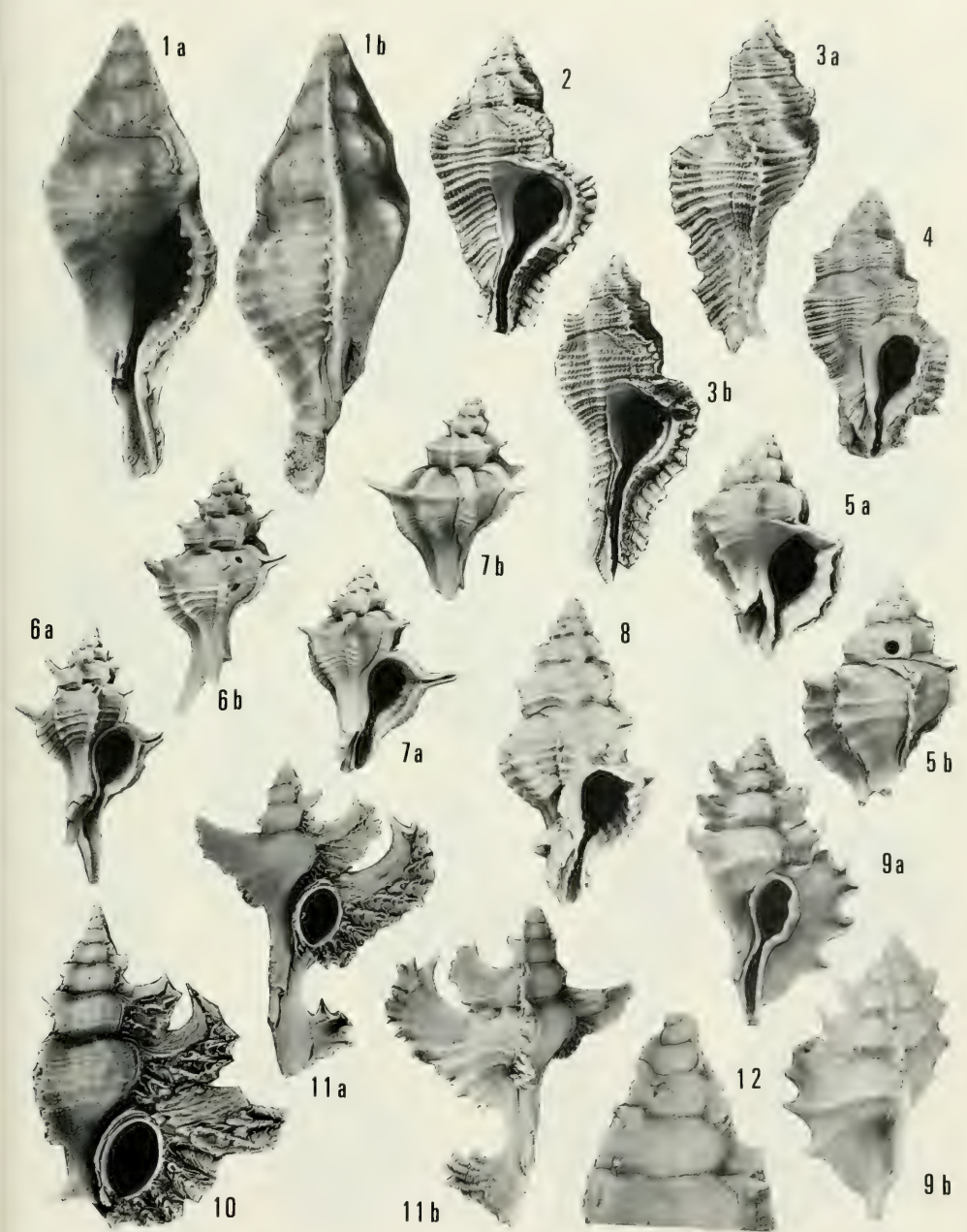


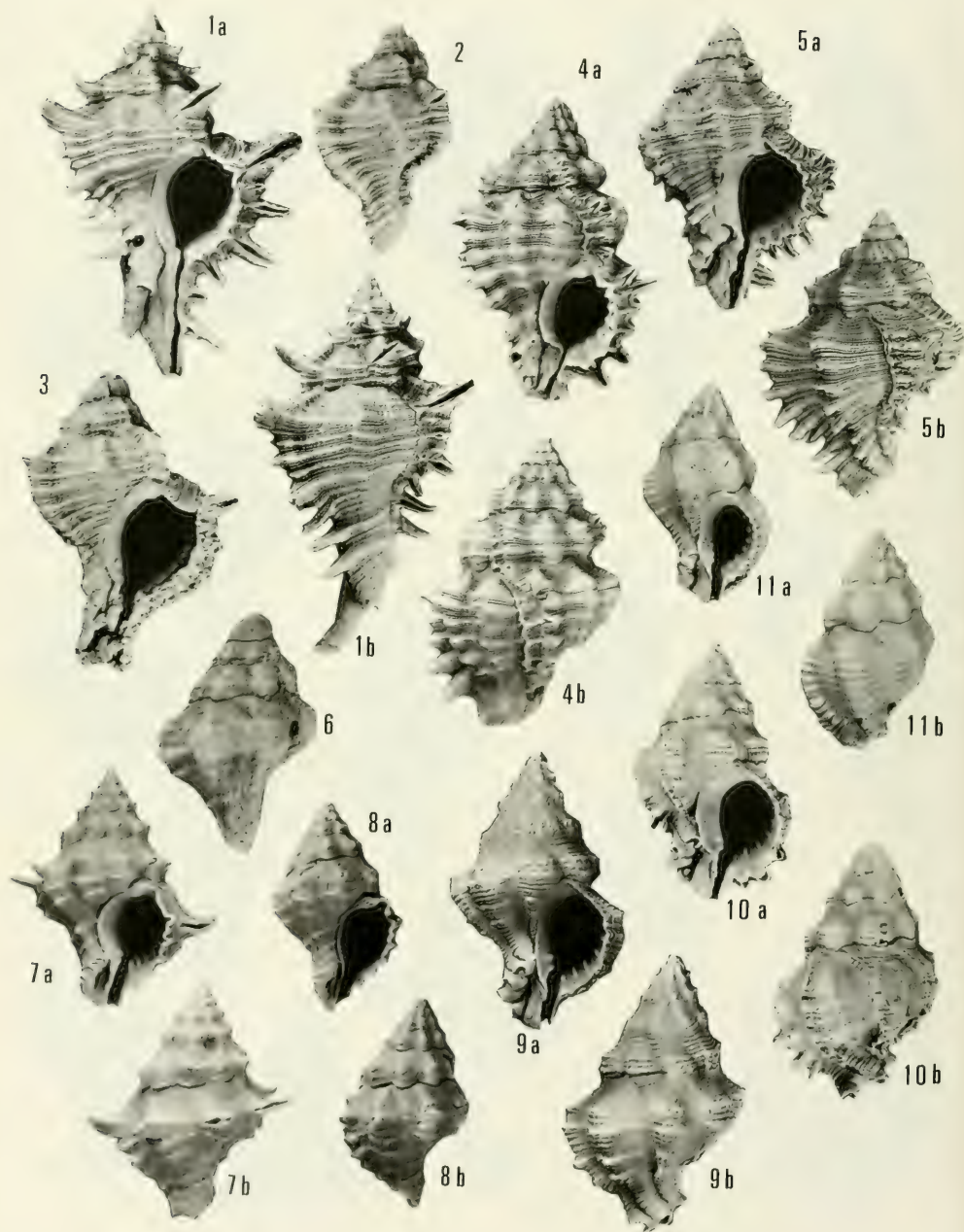
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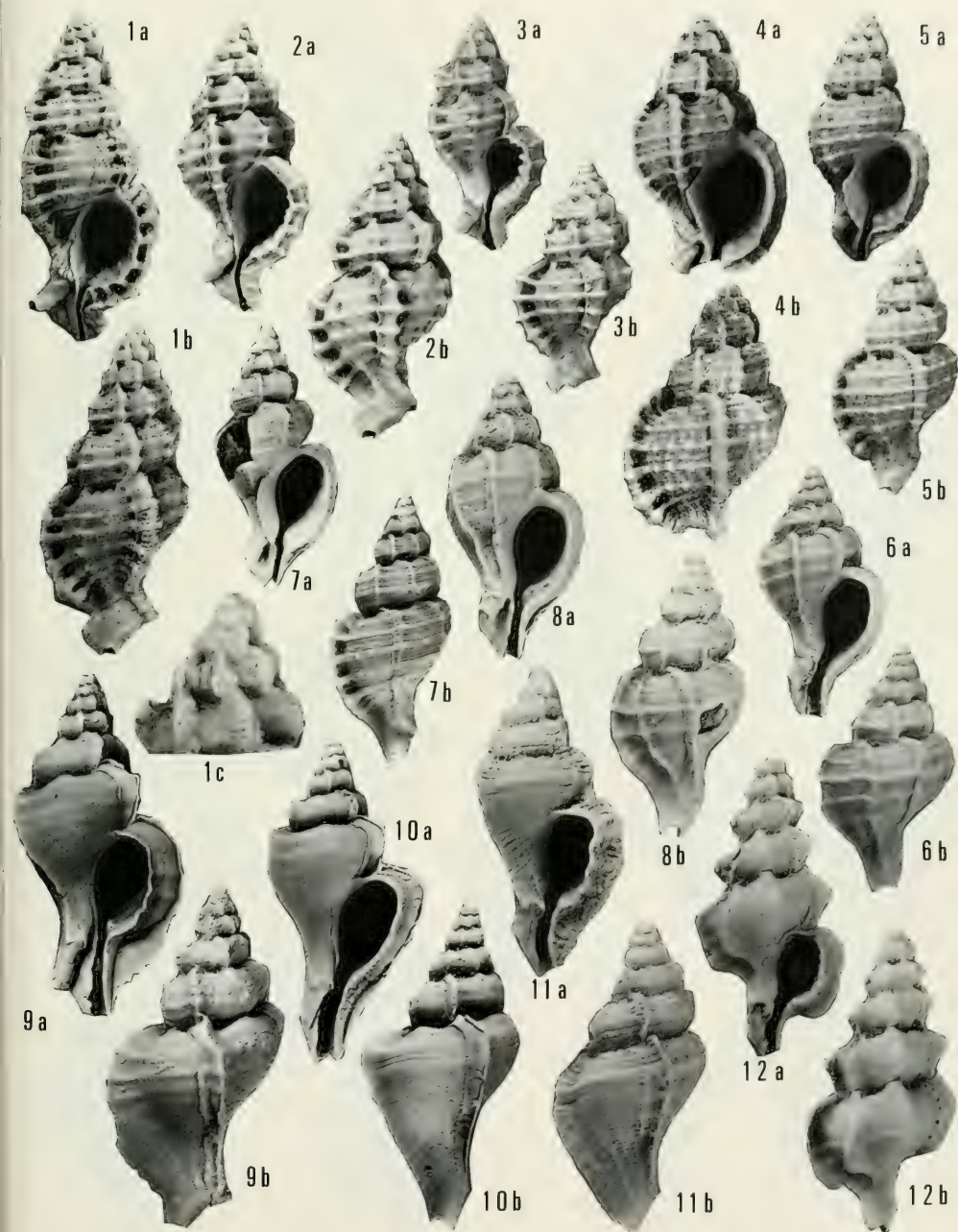


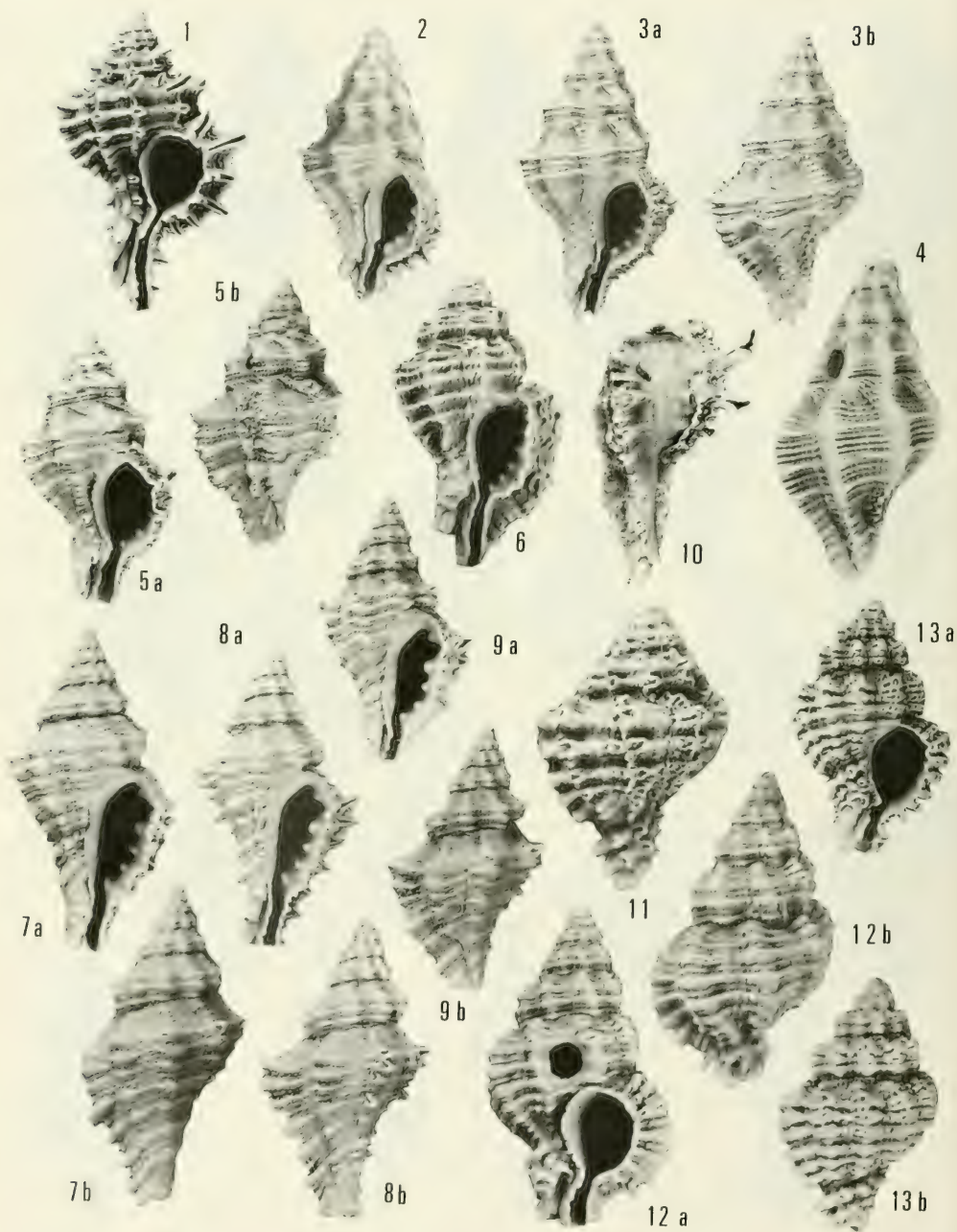
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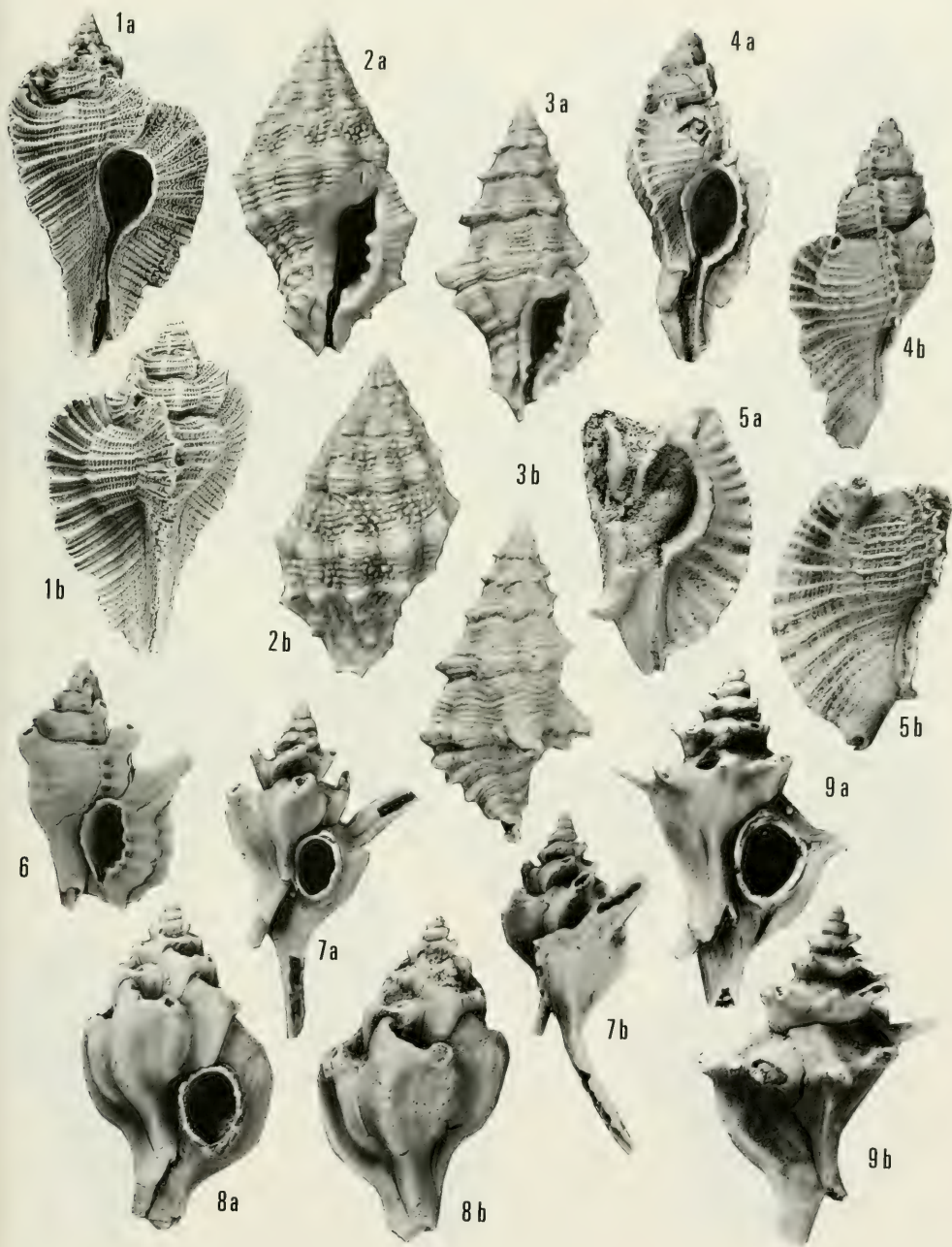


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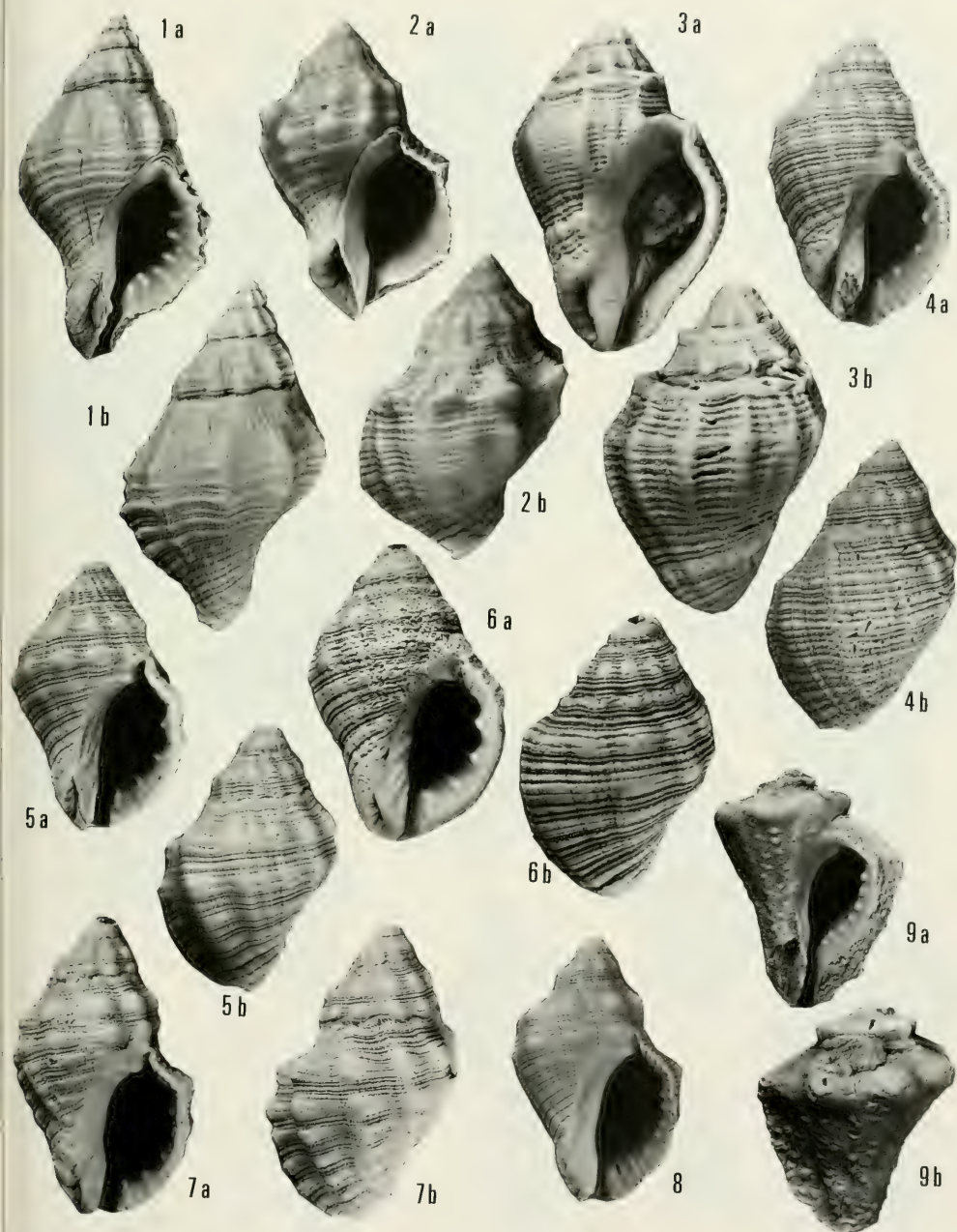


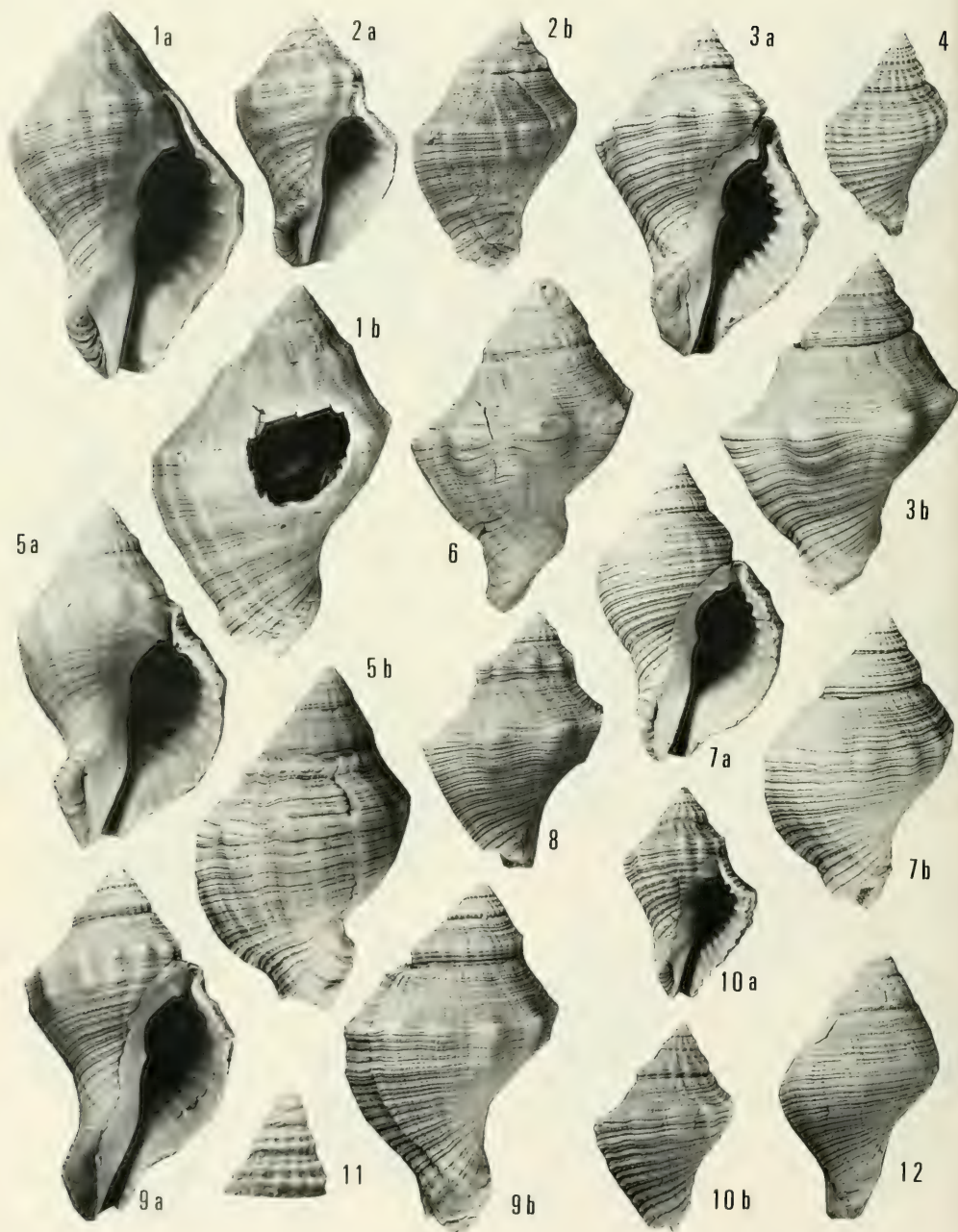
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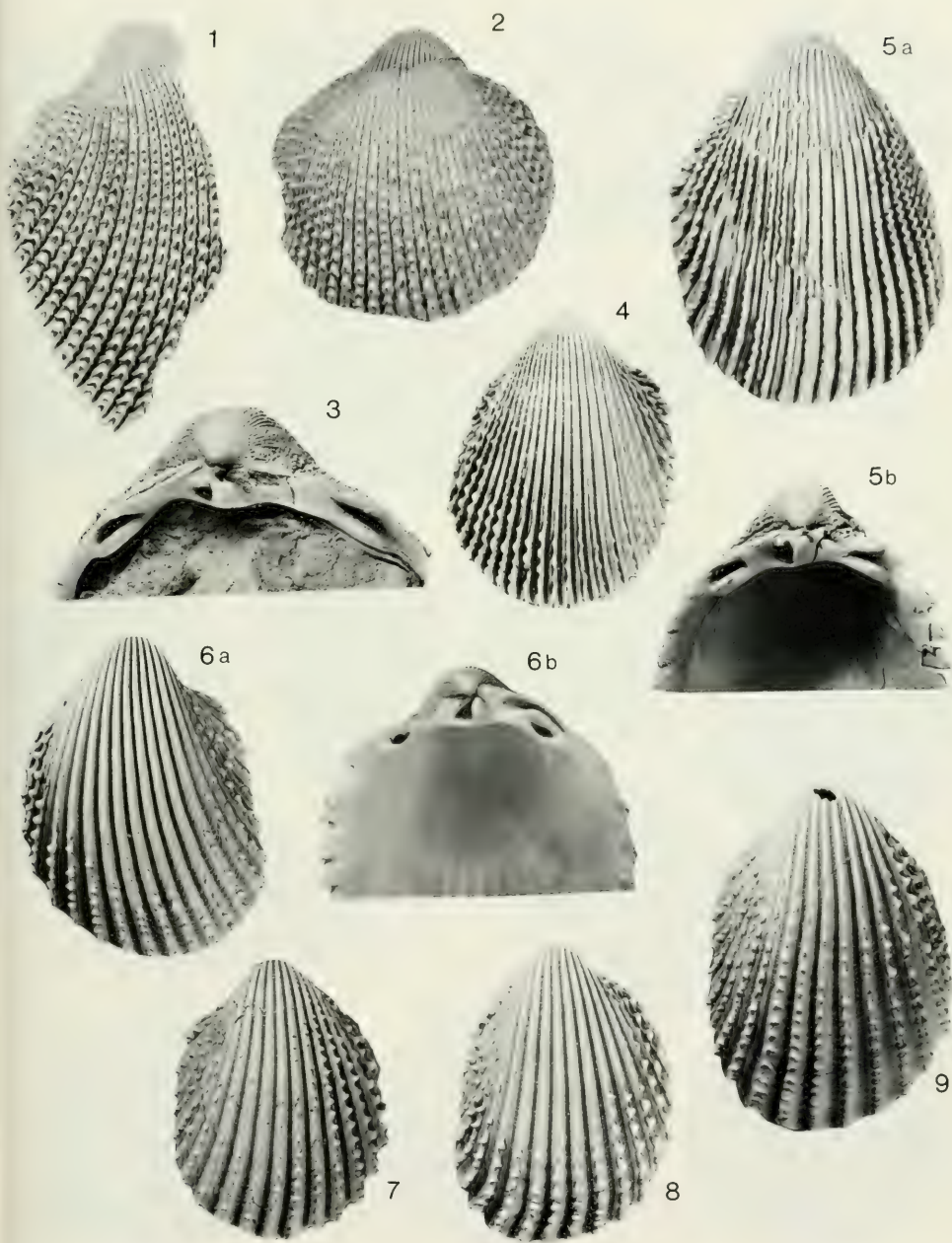


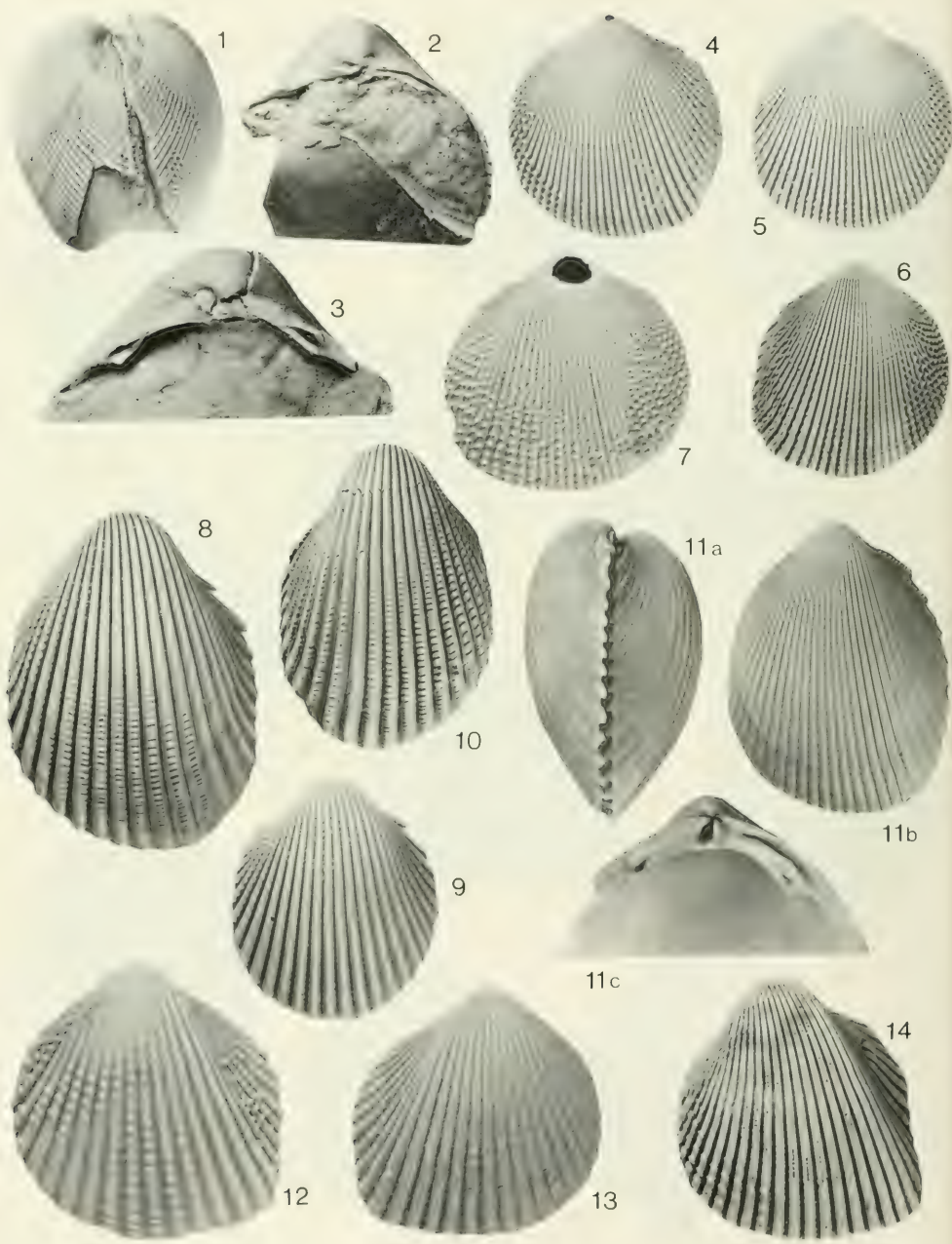
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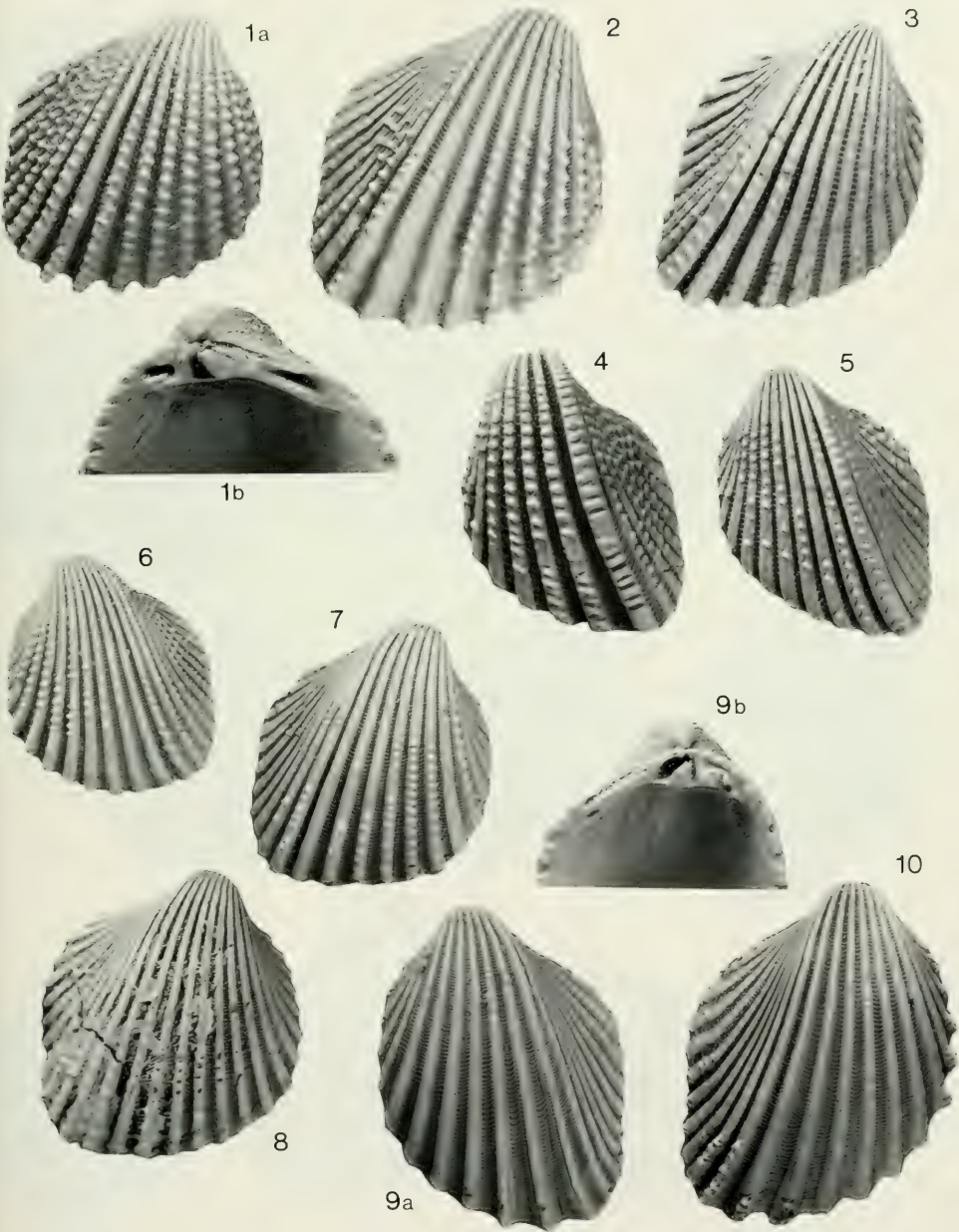


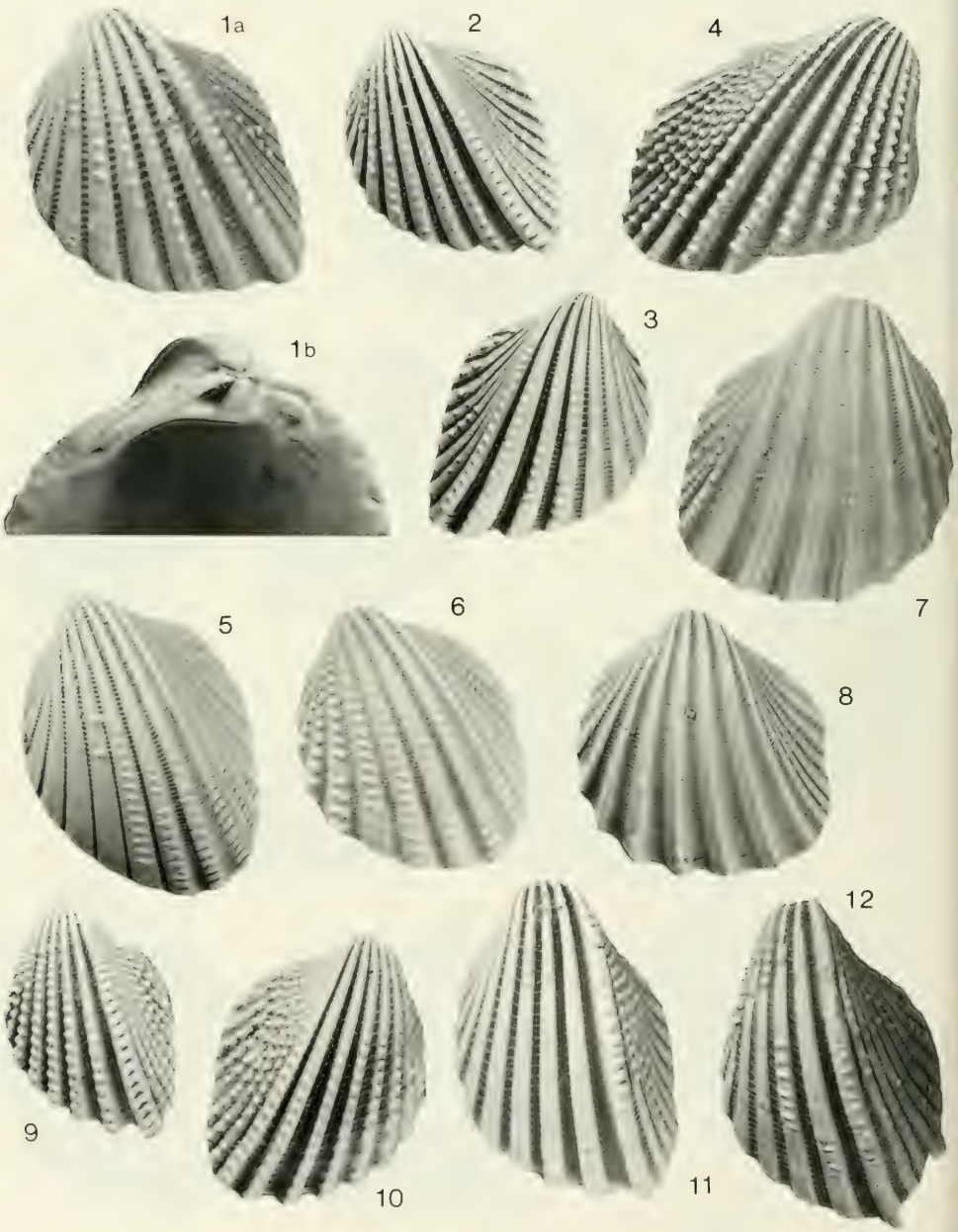
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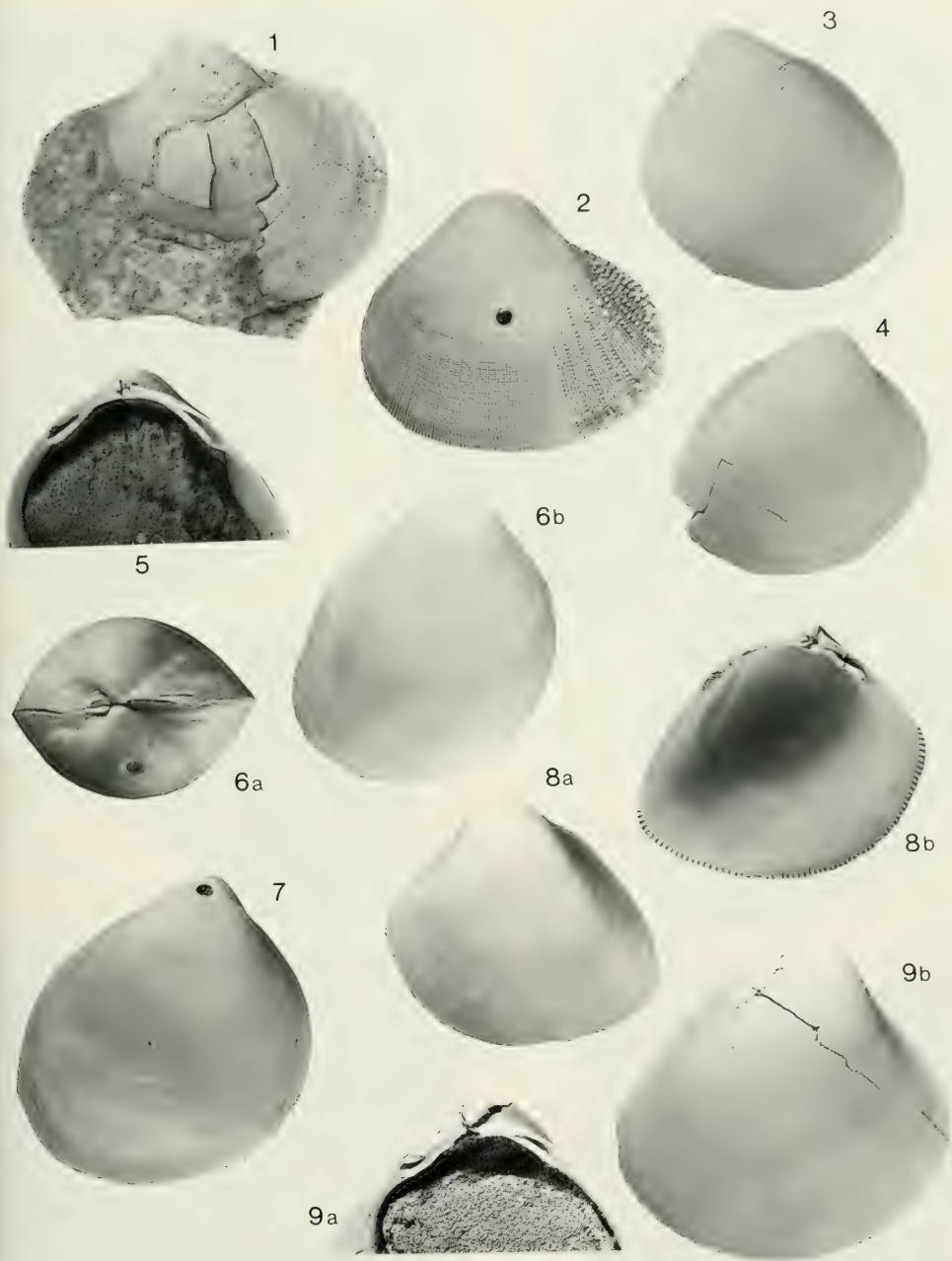


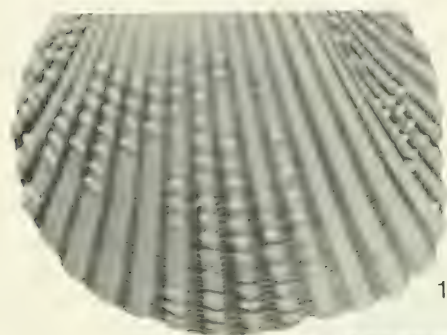
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11. Left valve, USNM 113800 (holotype), $\times 4$. ?Arroyo Hondo, Río Yaque del Norte area, Baitoa Formation, locality unknown, ?ex Bland and Rowell Collection. Length 10.0 mm, height 13.8 mm, diameter 6.2 mm.	
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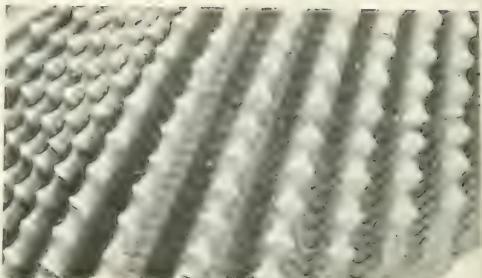
EXPLANATION OF PLATE 17

Figure	Page
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Left valve, USNM 416227 (hypotype), $\times 2$. Santiago-San Jose de las Matas road, Gurabo Formation, locality TU 1206. Length (incomplete) 24.2 mm, height (incomplete) 23.7 mm, diameter 7.5 mm.	
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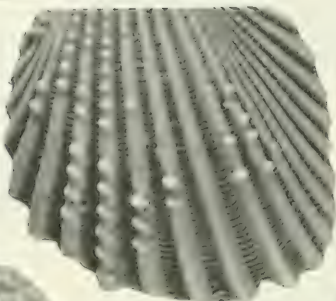




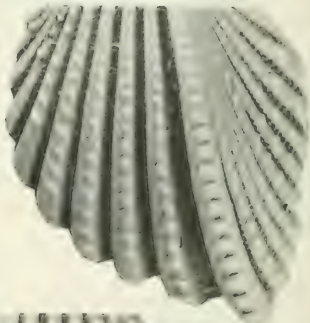
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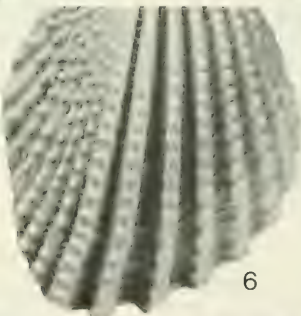
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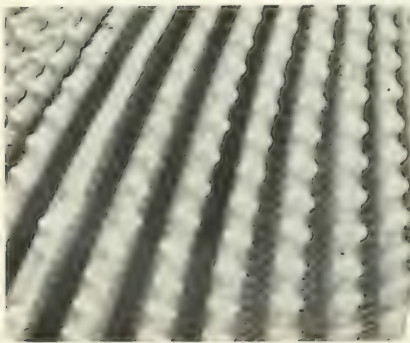
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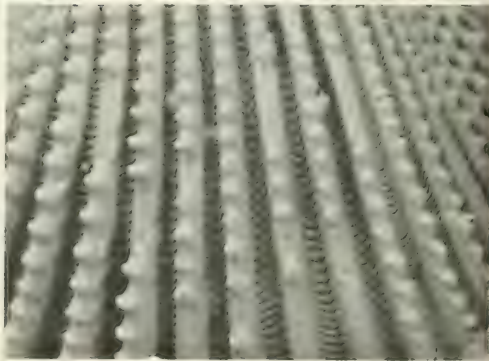


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EXPLANATION OF PLATE 18

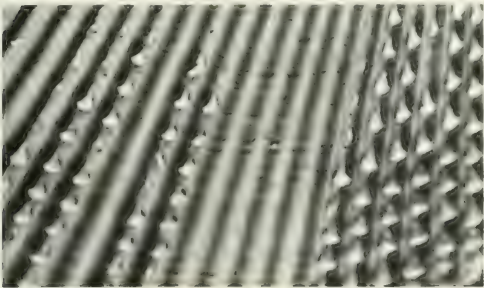
Enlargement of Various Species showing Intritacalx

Figure	Page
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Left valve, USNM 416210 (hypotype), $\times 6$. Río Yaque del Norte, unnamed formation, locality TU 1446. Length 12.0 mm, height 11.9 mm, diameter 4.5 mm.	
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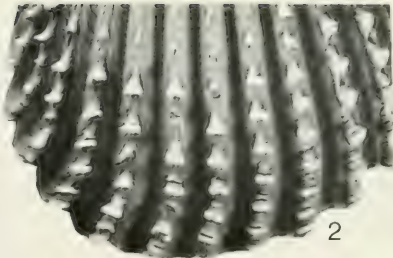
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Enlargement of Various Species showing Surface Ornament

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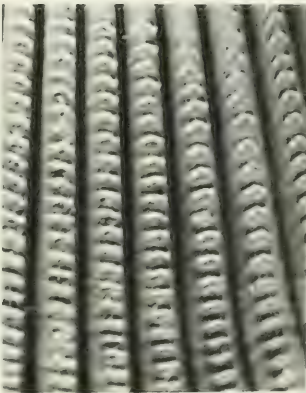
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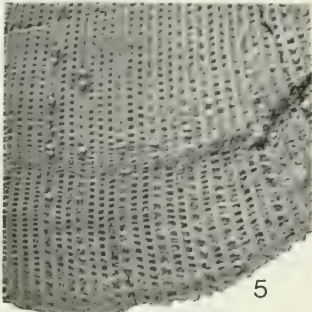
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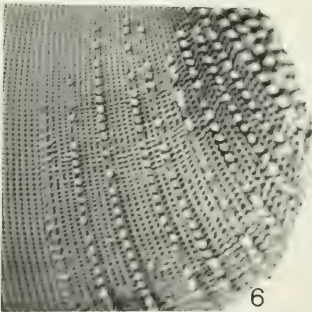
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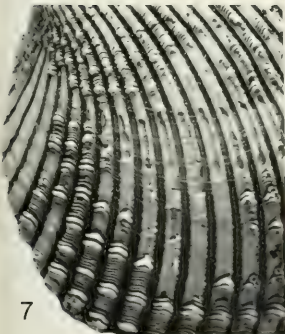
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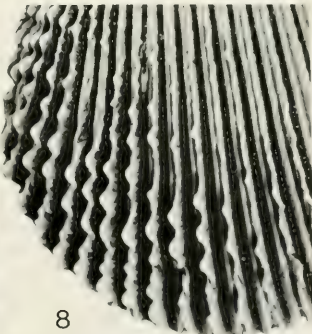
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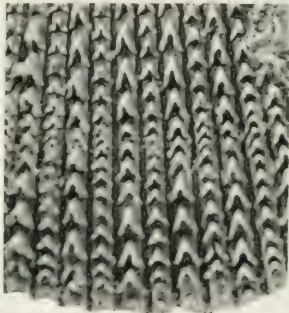
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<i>Chicoreus (Phyllonotus)</i> Swainson, 1833	38,39,42
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<i>eversoni</i> (D'Attilio, Mayers, and Shasky, 1987)	40
<i>globosus</i> (Emmons, 1858)	40
<i>infrequens</i> (Vokes, 1963b)	2
<i>leonensis</i> Vokes, 1967c	22,34,39
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<i>oculatus</i> (Reeve, 1845)	40,41
<i>peratus</i> (Keen, 1960)	40
<i>pomatus</i> , n. sp.	2
<i>pomum</i> (Gmelin, 1791)	2
<i>Chicoreus (Siratus)</i> Jousseaume, 1880	25,29-31,42,43,49
<i>alabaster</i> (Reeve, 1845)	29,50
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<i>antillarum</i> (Hinds, 1844)	45,48
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<i>Chicoreus (Chicoreus)</i>	34,42	<i>Habana</i>	122
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<i>Murex (Pteronotus)</i>	42	<i>tectum</i> Kiener	91
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<i>Chicoreus (Chicoreus)</i>	2, 18,22,31,32,33,37	<i>D'Attilio (1982)</i>	73,81,82
<i>Murex (Phyllonotus)</i>	31	<i>D'Attilio (1985)</i>	54
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<i>coronata</i> ,		<i>D'Attilio and Radwin (1971)</i>	58,101,111
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<i>Thais (Thaisella)</i>	85	<i>D'Attilio, Myers, and Shasky (1987)</i>	40
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<i>Chicoreus</i>	34,35,42,42	<i>Dall (1881)</i>	124,125
<i>Chicoreus (Chicoreus)</i>	3, 5,22,34,35,42,43,56	<i>Dall (1886)</i>	125
<i>Cosman, Dieter</i>	9	<i>Dall (1888)</i>	78,79
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<i>Chicoreus</i>	35,36	<i>Dall (1889b)</i>	126
<i>Chicoreus (Chicoreus)</i>	2, 22,35,36,53	<i>Dall (1890-1903)</i>	
<i>Cossmann (1903)</i>	73,78,80,84	42,43,45,57-59,65,75,81,91,92,95,96,98,101,104-106,109-114,117-120,124,125,127,129	
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<i>Costa (1776)</i>	24	<i>Dall (1901)</i>	113,129
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<i>alabastrum</i> (Adams, 1864)	60	Las Charcas	115
<i>antecessor</i> Vokes, 1975	62	Los Quemados	7,8,12-16,18,19,39,42,51,53-55,58-60,67,69,70,87-89,92,93,96,104,105,112,118,125,126,129
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<i>engonatus</i> (Dall, 1892)	59,60	Moca	7,96,110
<i>garrardi</i> Vokes, 1985	61	Moncion	7,96,110
<i>granulatus</i> , n. sp.	60,61	Naranjo ò Bajón	90
<i>olssoni</i> , n. sp.	59-61	Navarrete	7,96
<i>oxum</i> Petuch, 1979	62	Paso de los Perros	110
<i>pauperculus</i> (Adams, 1850)	60	Río Amina	7,18,27,28,30,33,44,46,54,56,57,64,73,96,97,113,114,128,129
<i>scalaroides</i> (Blainville, 1829)	60	"La Represa"	61
<i>tenellus</i> (Mayer, 1869)	60	Potrero	8,18,28,29,34,35,56,61,114,119
<i>Dermomurex</i> (<i>Dermomurex</i>) Monterosato, 1890	59,60,61	Río Bao	32,34,66,75,80,91,107,119,130
<i>alabastrum</i> (Adams, 1864)	59	Río Cana	7,12,23,27,29-31,33,38,40,43,45,46,60,62,63,65,68,71,72,75,84,86,88,89,93,96-99,104,106,108,109,112-116,119,121,127-130
<i>cracentis</i> , n. sp.	7 5,22,60,61	Caimito	12,16,30,42,71,108,111
<i>engonatus</i> (Dall, 1892)	59	Río Guayubin	7,96
<i>garrardi</i> Vokes, 1985	61	Río Gurabo	7,8,14-16,18-21,23,27-31,33,36,37,39-41,43,44,46,47,49,51-55,57,59,60,62-65,67-70,72,73,75,77,78,80,81,83,87-89,92-94,96-99,101,104-106,111-115,118,121-123,125,126,128-130
<i>granulatus</i> , n. sp.	7 5,22,60	Gurabo Adentro	8,13-15,57
<i>olssoni</i> , n. sp.	7 5,6,22,59,60	Gurabo Afuero	10,11,37,41,48,77,80
<i>pauperculus</i> (Adams, 1850)	60	Río Mao	7,12,18,23,27,29,30,33,46,50,51,54,56,73,75,80,81,90,96-99,101,104,109,110,113-115,128-130
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<i>Dermomurex</i> (<i>Trilatelata</i>) Berry, 1964	61,62	Bluff 1 of Maury (1917)	18,28,29,44,45,49,79,98,129
<i>antecessor</i> Vokes, 1975	62	Bluff 2 of Maury (1917)	18,114
<i>jani</i> (Bellardi, 1872)	62	Bluff 3 of Maury (1917)	18,29,98,110,113
<i>neglecta</i> (Habe and Kosuge, 1970)	61	Mao Adentro	12,18,29,98
<i>oxum</i> Petuch, 1979	62	Paso Chorrera	44,49
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<i>diomedea</i> , <i>Murexiella</i>	64	Arroyo López	20
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<i>domingensis</i> ,			
<i>Chicoreus</i>	25,27,28,44-50		
"fat" morphotype	47		
"slender" morphotype	47		
<i>Chicoreus</i> (<i>Siratus</i>)	4 6,18,22,25,27,29,41,43,44-46,49,51		
"fat" morphotype	45		
"slender" morphotype	45		
<i>Murex</i>	6,25,27,28,43-45,49,50		
<i>Murex</i> (<i>Murex</i>)	26,27,43		
<i>domingensis</i> (cf.), <i>Murex</i>	46		
" <i>domingensis</i> / <i>formosus</i> ", " <i>Chicoreus</i> (<i>Siratus</i>)"	45,47		
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Rio Guanajuma	57	<i>Cardium</i>	124
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San Cristobal	27,66,67,76,77,94	<i>Dermomurex</i>	59,60
southwestern, Playa las Salinas	123	<i>Dermomurex (Dermomurex)</i>	59
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<i>dominicanum</i> ,		<i>Typhis</i>	77
<i>Cardium</i>	95,110	<i>Typhis (Talityphis)</i>	77
<i>Cardium (Trachycardium)</i>	110	<i>eumekes</i> , <i>Chicoreus (Siratus)</i>	3
<i>Trachycardium (Mexicardia)</i>	14,19	<i>euracantha</i> , <i>Spinidrupa</i>	5,22,51,52
<i>dominicanum costaricanum</i> , <i>Trachycardium</i>	99,101,102,105,109,110	<i>euracanthus</i> , <i>Murex</i>	89
<i>dominicanum dominicanum</i> , <i>Trachycardium</i>	105,110	Europe	88
<i>dominicense</i> ,		<i>eversoni</i> , <i>Chicoreus (Phyllonotus)</i>	54,63,88
<i>Cardium</i>	96,107	<i>expansus</i> ,	40
<i>Cardium (Trachycardium)</i>	96,106	<i>Talityphis</i>	77
<i>Trachycardium (Dallocardia)</i>	14	<i>Typhis (Talityphis)</i>	10
<i>Trachycardium (Trachycardium)</i>	98,102,106	<i>Typhis</i>	23,41,75,76,77
<i>dominicense dominicense</i> , <i>Trachycardium (Dallocardia)</i>	106		47,75-78
<i>dominicensis</i> ,	107	<i>exquisita</i> , <i>Murexiella</i>	66
<i>Paziella (Dallimurex)</i>	55	<i>faceta</i> , <i>Murexiella</i>	65
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<i>Trophon</i>	16,22,35,50,55,56	<i>Murex</i>	31
" <i>Trophon</i> "	55,56	<i>Murex (Haustellum)</i>	31
<i>Donax</i> Linnaeus, 1758	121	<i>Fasciolaria</i>	92
Dorreen (1979)	9	<i>woodii</i> Gabb, 1860	90
<i>drezi</i> ,		<i>Fasciolina</i> Conrad, 1867	90
<i>Favartia</i>	72	<i>Favartia Jousseaume</i> , 1880	69,70,71
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<i>Drupella</i> Thiele, 1925	84	<i>drezi</i> (Vokes and D'Attilio, 1980)	72
Dubar (1958)	65	<i>germainae</i> (Vokes and D'Attilio, 1980)	72
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<i>dujardinioides</i> ,		sp. of Perrilliat (1972)	64
<i>Chicoreus</i>	33,34,43	<i>zalaya</i> , n. sp.	71
<i>Chicoreus (Chicoreus)</i>	2	<i>Favartia (Favartia) Jousseaume</i> , 1880	70,71
Dunker (1861)	22,33,34,39	sp.	8
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Dunker (1883)	36,37	<i>Favartia (Pygmaeapterys) Vokes</i> , 1978	5,23,70
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<i>eburneum</i> forma <i>lymani</i> , <i>Cerithium</i>	83	<i>drezi</i> (Vokes and D'Attilio, 1980)	72
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		<i>finlayi</i> , <i>Murex</i>	83
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